

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
18 March 2004 (18.03.2004)

PCT

(10) International Publication Number  
**WO 2004/021899 A1**

(51) International Patent Classification<sup>7</sup>: **A61B 17/56**

(21) International Application Number:  
PCT/US2002/028106

(22) International Filing Date:  
5 September 2002 (05.09.2002)

(25) Filing Language: English

(26) Publication Language: English

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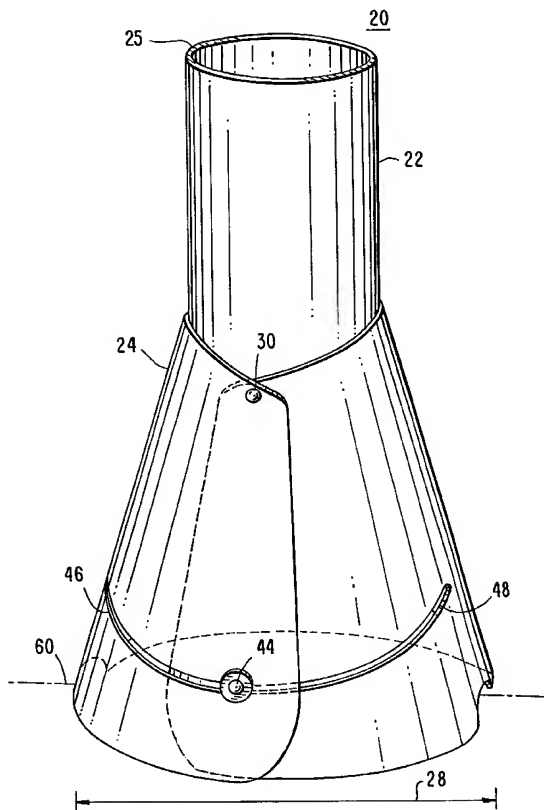
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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK,

[Continued on next page]

(54) Title: SYSTEM AND METHODS FOR PERFORMING MINIMALLY-INVASIVE SURGICAL PROCEDURES



(57) Abstract: Systems and methods for performing surgical procedures on bone structures located within body tissue including an expandable conduit (22) comprising a wall portion (22) defining an internal passage therethrough and an initial configuration having a first cross-sectional area at a distal portion (24) thereof for percutaneous insertion into the body tissue. The wall portion (22) is movable against the body tissue to a second configuration having an enlarged cross-sectional area at the distal portion (22) thereof. An elongated member (650) and a first and second fastener (600) are configured for insertion into the internal passage. The first and second fasteners (600) are configured for fixation to the bone portion. The fastener (600) defines a recess for receiving the elongated member (650) therein. A driver member (660) is used to secure the clamping member (610) to the housing (604). The first and second bone portions are preferably first and second vertebrae.

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TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

**Published:**

— *with international search report*

## SYSTEM AND METHODS FOR PERFORMING MINIMALLY-INVASIVE SURGICAL PROCEDURES

### BACKGROUND OF THE INVENTION

#### 5 Field of the Invention

This invention relates to methods and apparatus for performing minimally invasive surgery, and more particularly to instruments for providing endoscopic access to body tissues and performing procedures on bone structures of a patient.

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#### Background Information

Spinal surgery presents significant difficulties to the physician attempting to reduce chronic back pain or correct spinal deformities without introducing additional trauma due to the surgical procedure itself. In order to access  
15 the vertebrae to perform spinal fixation, discectomy or related procedures, the physician is typically required to make large incisions and cut or strip muscle tissue surrounding the spine. In addition, care must be taken not to injure nerve tissue in the area. Consequently, traditional surgical procedures of this type carry high risks of scarring, pain, significant blood loss, and extended recovery times.

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Apparatus for performing minimally invasive techniques have been proposed to reduce the trauma of posterior spinal surgery by reducing the size of the incision and the degree of muscle stripping in order to access the vertebrae. U.S. Patent 5,954,635 to Foley et al., entitled "Devices and Methods for Percutaneous Surgery," for example, describes an elongated cannula that is inserted into the spinal  
25 area to provide a working channel to allow the introduction of optics and surgical instrumentation to the operative site.

A significant disadvantage of the cannula described in the '635 patent is that the cannula which is used to provide access for the surgical instrumentation has a constant diameter. Accordingly, the cannula must be narrow in order to provide a  
30 small entry profile. As a result, the cannula provides minimal space for the physician to observe the body structures and manipulate surgical instrumentation in order to perform the required procedures. For spinal fixation procedures, where it is necessary to view two or more vertebrae and to introduce pedicle screws, rods, as well as other

large spinal fixation devices, a narrow cannula is typically insufficient to perform this procedure.

Several tubular devices have been introduced which are inserted transcutaneously and which expand to provide improved visualization and/or access. Many of these apparatus are designed for use in bladder surgery or with other soft tissue. Consequently, they are made of softer materials to avoid damaging such delicate tissues. For example, U.S. Patent 5,707,359 to Bufalini, entitled "Expanding Trocar Assembly," describes a device for the removal of tissues or organs from a surgical cavity. The expandable portion of the device includes a plurality of plastic ribs interconnected by plastic webbing. Instruments such as these are typically unsuitable for use in spinal surgery, or other types of surgery, in which it is necessary to create and support a surgical space surrounded by resistant tissue, e.g., muscle tissue, and that is significantly large enough to perform sophisticated surgical techniques which incorporate a number of surgical instruments and visualization tools.

U.S. Patent 6,187,000 to Davison et al., entitled "Cannula for Receiving Surgical Instruments," discloses a novel cannula or retractor which receives surgical instruments for performing a surgical procedure on a body. The cannula or retractor includes an expandable portion for enabling an increase in the cross-sectional area of the passage at the distal end. The expandable portion of the tube structure, when expanded, provides an enlarged operative space.

The installation of spinal fixation assemblies, for example, requires significant space to access the vertebral bone, insert the pedicle screws, perform distraction or compression of the vertebrae, and attach the rod members. This installation is complicated by the reduced access provided by narrow cannulas or tubular retractors. The '635 patent describes a method for performing surgical procedures through the cannula. Such a procedure includes the insertion of optics, tools, bone screws, and implant devices through the cannula to the operative site. However, this method has significant disadvantages. For example, the '635 patent does not describe steps for installing rods or other connecting means between pedicle screws to stabilize adjacent vertebrae. Moreover, no specialized tools for installing such rods, or for distracting or compressing vertebrae in a confined space are shown in the '635 patent. Other surgical procedures with minimally-invasive features use

techniques or instrumentation that are unfamiliar to physicians accustomed to corresponding open surgical procedures.

Accordingly, there is a need in the art for an integrated system of surgical instrumentation designed to function in a complementary manner to perform procedures such as spinal fixation through narrow access channels.

### SUMMARY OF THE INVENTION

An object of the present invention is to provide access and an increased surgical space to perform minimally invasive surgical procedures.

Another object of the present invention is to provide apparatus for providing such access which is simple in construction and sufficiently rigid to create and support desired surgical space in resistant tissue such as muscle tissue.

A further object of the invention is to provide instrumentation for performing procedures with substantially reduced incision size when compared to open procedures.

A still further object of the invention is to provide a minimally invasive surgical system and methods that incorporate instruments and techniques which are unique and novel, but which correspond to procedures used in open surgery.

These and other objects of the invention, which will become apparent with reference to the disclosure herein, are accomplished by a system for performing, through a minimal incision, surgical procedures on bone structures, such as vertebrae, located beneath body tissue in a patient. An expandable conduit comprises a wall portion defining an internal passage therethrough. In a first configuration, the wall portion has a first cross-sectional area at a distal portion thereof for percutaneous insertion into the body tissue. The wall portion is movable against the body tissue, which may be resistant muscle tissue, for example, to a second configuration having an enlarged cross-sectional area at the distal portion thereof. The wall portion in the second configuration is at least partially supported in position by the body tissue. With this feature, the expandable conduit is maintained approximately in position in the body tissue, and thus the physician is freed from the need to support or hold the expandable conduit after it is installed. Prior art cannulas do not provide this feature and tend to tip over or change position within the body if they are not supported. This movement of prior art cannulas that could injure or otherwise cause trauma to surrounding tissue is avoided by the present invention.

The system further includes an elongated member and a first and second fastener configured for insertion into the internal passage of the expandable conduit. The fasteners each comprise a screw portion for fixation to the bone structure, and a housing movably mounted with respect to the screw portion and defining a longitudinal axis. The housing defines a recess for receiving the elongated member therein in an orientation substantially transverse to the longitudinal axis. The fastener further comprises a biasing member mounted in the housing to apply a biasing force to drive a spacer member into frictional engagement with the screw member to restrict movement of the housing with respect to the screw portion. A clamping member is attachable to the housing to clamp the elongated member, the spacer member, the screw member and the housing into fixed engagement. In one exemplary embodiment, the system is configured to perform a spinal fixation, in which the first fastener is secured to a first vertebra, and the second fastener is secured to a second vertebrae. In another exemplary embodiment, a multi-level spinal fixation may be performed including three fasteners secured to three bone portions, such that a first fastener is secured to a first vertebrae (such as, e.g., L4), a second fastener is secured to a second bone portion (such as, e.g., L5), and a third fastener is secured to a third vertebrae (such as, e.g., S1).

A driver member is configured to secure the clamping member to the housing. A pusher member cooperative with the driver member is configured to apply a longitudinal force to urge the elongated member in the recess in the housing.

In one embodiment, the wall portion of the expandable conduit comprises a flexible sheet defining first overlapping configuration when in the first configuration and a second overlapping configuration when in the second configuration. The wall portion may comprise a first and a second cooperating slot and a pin slidable in the first and second cooperating slots to allow the wall portion to move between the first and second configurations. The wall portion of the expandable conduit may also be configured to resiliently expand from the initial cross-sectional area to the second, enlarged cross-sectional area. The wall portion of the expandable conduit may also define a notch portion at a distal portion thereof configured to allow a portion of the elongated member to pass therethrough.

The system may further comprise an expander instrument having a remotely actuable distal portion movable between an approximated configuration and a spaced apart configuration, which is configured for insertion into the internal

passage of the expandable conduit to expand the cross-sectional area defined by the wall portion thereof. The expandable conduit may have a distal wall portion movable about the longitudinal axis relative to a proximal wall portion. The expander apparatus may be inserted into the expandable conduit and engage the distal wall portion to cause such relative movement of the distal portion.

An adjustment apparatus may be provided comprising a spacer member for applying a force to the second housing in a direction substantially transverse to the second longitudinal axis to move a first bone portion relative to a second bone portion. The adjustment apparatus may further comprise a driver member cooperative with the spacer member for securing the first clamping member relative to the first housing while the spacer member applies the force to the second housing.

An apparatus for supporting an endoscope may be provided which engages a proximal portion of the expandable conduit. The apparatus may comprise a base portion defining a bore in communication with the internal passage of the expandable conduit, and an endoscope mounting member movably mounted relative to the base for supporting an endoscope within the internal passage of the expandable cannula. The base portion may be rotatable about a longitudinal axis of the expandable conduit. The endoscope mounting member may also be movable relative to the base along the longitudinal axis and/or movable relative to the base transverse to the longitudinal axis.

In accordance with the invention, the objects of providing a system and methods for providing a subcutaneous surgical space for performing a surgical procedure have been met. Further features of the invention, its nature and various advantages will be more apparent from the accompanying drawings and the following detailed description of illustrative embodiments.

#### BRIEF DESCRIPTIONS OF THE DRAWINGS

Further objects, features and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying figures showing illustrative embodiments of the invention, in which:

FIG. 1 is a perspective view of the surgical system and procedure in accordance with the present invention.

FIG. 2 is a perspective view of the expandable conduit in a reduced profile configuration in accordance with the present invention.

FIG. 3 is a perspective view of the expandable conduit in a first enlarged configuration in accordance with the present invention.

5           FIG. 4 is a perspective view of the expandable conduit in a second enlarged configuration in accordance with the present invention.

FIG. 5 is a view of the cannula skirt in accordance with the present invention.

10           FIG. 6 is a view of another embodiment of the cannula skirt in accordance with the present invention.

FIG. 7 is a perspective view of yet another embodiment of the expandable conduit in an enlarged configuration in accordance with the present invention.

15           FIG. 8 is an enlarged sectional view of the expandable conduit of FIG. 7 taken along lines 8-8 of FIG. 7 in accordance with the present invention.

FIG. 9 is a sectional view of the expandable conduit of FIG. 7 taken along lines 9-9 of FIG. 7 in accordance with the present invention.

20           FIG. 10 is a perspective view of a further embodiment of the expandable conduit in an enlarged configuration in accordance with the present invention.

FIG. 11 is an enlarged sectional view of the expandable conduit of FIG. 10 taken along lines 11-11 of FIG. 10 in accordance with the present invention.

FIG. 12 is a sectional view of the expandable conduit of FIG. 10 taken along lines 12-12 of FIG. 10 in accordance with the present invention.

25           FIG. 13 is a view of a portion of a further embodiment of the expandable conduit in accordance with the present invention.

FIG. 14 is a view of a portion of a still further embodiment of the expandable conduit in accordance with the present invention.

30           FIG. 15 is a sectional view illustrating an early stage of the procedure in accordance with the present invention.

FIG. 16 is a side view of another apparatus in a reduced profile configuration in accordance with the present invention.

FIG. 17 is a side view of the apparatus of FIG. 16 in an expanded configuration in accordance with the present invention.



FIG. 18 is a sectional view of the apparatus of FIGS. 16-17 inserted into the expandable conduit of FIG. 2 in accordance with the present invention.

FIG. 19 is a sectional view of the apparatus of FIGS. 16-17 inserted into the expandable conduit of FIG. 2 in accordance with the present invention.

5           FIG. 20 is a perspective view with parts separated of further apparatus in accordance with the present invention.

FIG. 21 is a top view of the apparatus of FIG. 20 illustrated with other apparatus in accordance with the present invention.

10           FIG. 22 is a side view of the apparatus of FIG. 20 illustrated with other apparatus in accordance with the present invention.

FIG. 23 is an enlarged perspective view of a component of the apparatus of FIG. 20 in accordance with the present invention.

FIG. 24 is a perspective view of further apparatus in accordance with the present invention.

15           FIG. 25 is a view in partial section of a later stage in the procedure in accordance with the present invention.

FIG. 26 is a perspective view of further apparatus in accordance with the present invention.

20           FIG. 27 is a perspective view with parts separated of the apparatus of FIG. 26 in accordance with the present invention.

FIG. 27(a) is an enlarged side view of a component illustrated in FIG. 27, in accordance with the invention.

FIG. 28 is a perspective view of a further surgical instrument in accordance with the present invention;

25           FIG. 29 is an enlarged sectional view of the apparatus of FIGS. 26-28, illustrating a further stage of the procedure in accordance with the present invention.

FIG. 30 is side view of another surgical instrument in accordance with the present invention.

30           FIG. 31 is a view in partial section of a further stage in the procedure in accordance with the invention.

FIG. 32 is a side view of a further instrument in accordance with the present invention.

FIG. 33 is a perspective view similar to FIG. 31 illustrating the apparatus of FIGS. 26 and 32, in a further stage of the procedure in accordance with the present invention.

FIG. 34 is an enlarged sectional view of the apparatus of FIGS. 26 and 32, illustrating a still further stage in accordance with the present invention.

FIG. 35 is an enlarged sectional view similar to FIG. 34, illustrating a subsequent stage of the procedure in accordance with the present invention.

FIG. 36 is an enlarged view in partial section illustrating another stage in the procedure in accordance with the present invention.

FIG. 37 is a reduced scale view in partial section illustrating yet another stage in the procedure in accordance with the present invention.

Throughout the figures, the same reference numerals and characters, unless otherwise stated, are used to denote like features, elements, components or portions of the illustrated embodiments. Moreover, while the subject invention will now be described in detail with reference to the figures, it is done so in connection with the illustrative embodiments. It is intended that changes and modifications can be made to the described embodiments without departing from the true scope and spirit of the subject invention as defined by the appended claims.

## DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

This invention will be further understood in view of the following detailed description.

The exemplary embodiment of apparatus and procedures described herein will be discussed in terms of endoscopic and minimally invasive procedures and apparatus. However, many aspects of the present invention may find use in conventional, open procedures. In the drawings and description which follows, the term "proximal," as is traditional, refers to the end portion of the apparatus which is closest to the operator, while the term "distal" will refer to the end portion which is furthest from the operator.

Referring now in detail to the drawings, FIG. 1 illustrates an exemplary arrangement for performing the procedure in accordance with the invention. The patient P is typically placed in the prone position on operating table T, taking care that the abdomen is not compressed and physiological lordosis is preserved, as is known in the art. The physician D is able to access the surgical site

and perform the surgical procedure with the components of the system 10, which will be described in greater detail herein. The system 10 may be supported, in part, by a mechanical support arm A, such as the type generally disclosed in U.S. Patent No. 4,863,133, which is incorporated by reference in its entirety herein. The  
5 mechanical arm of this type is manufactured by Leonard Medical, Inc., 1464 Holcomb Road, Huntington Valley, PA, 19006. The physician D is able to view the procedure by reference to a monitor M, which displays the images captured by an endoscope and camera which will be described in greater detail herein. Alternatively, the physician D may view the surgical site through an eyepiece of the endoscope, or  
10 she may directly view the surgical site with loupes, microscope, or with the unaided eye.

The system and procedures will be described herein in connection with minimally invasive posterolateral spinal surgery. In particular, the procedure described herein is a two level posterolateral fixation of the spine involving the L4,  
15 L5 and S1 vertebrae. (In the drawings, the vertebrae will generally be denoted by reference letter V.) The usefulness of the inventive procedure is neither restricted to the posterolateral approach nor to the L4, L5 and S1 vertebra, but it may be used in other anatomical approaches and other vertebra within the cervical, thoracic and lumbar spine. The inventive procedure may be directed toward surgery involving one  
20 or more vertebral levels. It is also useful for anterior and lateral procedures. Moreover, it is believed that the invention is also particularly useful where any body structures must be accessed beneath the skin and muscle tissue of the patient, and where it is desirable to provide sufficient space and visibility in order to manipulate surgical instrumentation and treat the underlying body structures. For example,  
25 certain features or instrumentation described herein are particularly useful for a minimally invasive, e.g., arthroscopic procedures, in which the expandable distal portion of the expandable conduit prevents the instrument from dislodging or popping out of the operative site.

The system 10 includes an expandable conduit which provides a  
30 internal passage for surgical instrumentation to be inserted through the skin and muscle tissue of the patient P to the surgical site. The expandable conduit has a wall portion defining reduced profile configuration for initial percutaneous insertion into the patient. This wall portion may have a generally tubular configuration that may be

passed over a dilator that has been inserted into the patient to atraumatically enlarge an opening sufficiently large to receive the expandable conduit therein.

The wall portion of the expandable conduit is subsequently expanded to an enlarged configuration, by moving against the surrounding muscle tissue to at least partially define an enlarged surgical space in which the surgical procedures will be performed. In a sense, it acts as its own dilator. Typically, but not by way of limitation, the distal portion expands to a greater extent than the proximal portion, since the surgical procedures are to be performed at the surgical site adjacent the distal portion thereof.

While in the reduced profile configuration, the expandable conduit defines a first unexpanded configuration. Thereafter, the expandable conduit enlarges the surgical space defined thereby by engaging the tissue surrounding the conduit and displacing the tissue radially outwardly as the conduit expands. The expandable conduit may be sufficiently rigid to displace such tissue during the expansion thereof. The expandable conduit may be resiliently biased to expand from the reduced profile configuration to the enlarged configuration. In addition, the conduit may also be manually expanded with surgical instrumentation inserted therein, as will be described below. The surgical site is at least partially defined by the expanded conduit itself. During expansion, the conduit moves from the first overlapping configuration to a second overlapping configuration.

In addition to enlargement, the distal end portion of the expandable conduit may be configured for relative movement with respect to the proximal end portion in order to allow the physician to precisely position the distal portion at the desired location. This relative movement also provides the advantage that the proximal portion of the expandable conduit nearest the physician D may remain substantially stable during such distal movement. In an exemplary embodiment, the distal portion is a separate component which is pivotably or movably attached relative to the proximal portion. Alternatively, the distal portion is flexible or resilient in order to permit such relative movement.

An exemplary embodiment of the expandable conduit is illustrated in FIGS. 2-6 and designated by reference number 20. The expandable conduit 20 includes a proximal wall portion 22, which has a tubular configuration, and a distal wall portion, which is an expandable skirt portion 24. The skirt portion 24 is enlargeable from a reduced profile configuration having an initial dimension 26 and

corresponding cross-sectional area (illustrated in FIG. 2), to an enlarged configuration having a dimension 28 and corresponding cross-sectional area (illustrated in FIG. 4). The skirt portion 24 may be attached to the proximal cylindrical tube portion 22 with a rivet 30, pin, or similar connecting device to permit movement of the skirt portion  
5 24 relative to the proximal cylindrical tube portion 22.

In the exemplary embodiment, the skirt portion 24 is manufactured from a resilient material, such as stainless steel. The skirt 24 is manufactured so that it normally assumes an expanded configuration illustrated in FIG. 4. As illustrated in FIG. 3, the skirt portion 24 may assume an intermediate dimension 34 and  
10 corresponding cross-sectional area, which is greater than dimension 26 of the reduced profile configuration of FIG. 2, and smaller than dimension 28 of FIG. 4. Skirt portion 24 may assume the configuration of FIG. 3 when deployed in the patient in response to the force of the tissue acting on the skirt portion. The actual dimension 34 will depend upon several factors, including the rigidity of the skirt portion 24, the  
15 surrounding tissue, and whether such surrounding tissue has relaxed or tightened during the course of the procedure. An outer plastic sleeve 32 (illustrated in dashed line in FIG. 2) may be provided which surrounds the expandable conduit 20 and maintains the skirt 24 in the reduced profile configuration. The plastic sleeve 32 may have a braided polyester suture embedded within it (not shown), aligned substantially  
20 along the longitudinal axis thereof; such that when the suture is withdrawn, the sleeve 32 is torn, which allows the expandable conduit 20 to resiliently expand from the reduced profile configuration of FIG. 2 to the expanded configurations of FIGS. 3-4. While in the reduced profile configuration of FIG. 2, the skirt portion 24 defines a first overlapping configuration 33, as illustrated by the dashed line. As the skirt  
25 portion 24 resiliently expands, the skirt portion 24 assumes the second configuration 35, as illustrated in FIGS. 3-4.

The skirt portion 24 is sufficiently rigid that it is capable of displacing the tissue surrounding the skirt portion 24 as it expands. Depending upon the resistance exerted by surrounding tissue, the skirt portion is sufficiently rigid to  
30 provide some resistance against the tissue to remain the configurations of FIGS. 3-4. Moreover, the expanded configuration of the skirt portion 24 is at least partially supported by the body tissue of the patient. The rigidity of the skirt portion 24 and the greater expansion at the distal portion creates a stable configuration that is at least temporarily stationary in the patient, which frees the physician from the need to

actively support the conduit 20 until the endoscope mount platform 300 and support arm 400 are subsequently added (see FIGS. 21-22).

The skirt portion 24 of expandable conduit 20 is illustrated in an initial flattened configuration in FIG. 5. The skirt portion 24 may be manufactured from a sheet of stainless steel having a thickness of about 0.007 inches for skirt portions having a fully expanded dimension 28 of about 65mm in its unrestricted circular shape. The skirt portion 24 may also take on an oval shape having a longer dimension of about 85mm. An increased thickness, e.g., about 0.010 inches, may be used in connection with skirt portions having a larger diameter, such as about 65mm. Other materials, such as nitinol or plastics having similar properties, may also be useful.

As discussed above, the skirt portion 24 is attached to the proximal cylindrical portion 22 with a pivotable connection, such as rivet 30. A pair of rivet holes 36 are provided in the skirt portion 24 to receive the rivet 30. The two free ends 38 and 40 of the skirt portion 24 are secured by a slidable connection, such as second rivet 44 (not shown in FIG. 5, illustrated in FIGS. 2-4). A pair of complementary slots 46 and 48 are defined in the skirt portion 24 adjacent the end portions 38 and 40. The rivet 44 is permitted to move freely within the slots 46 and 48. This slot and rivet configuration allows the skirt portion 24 to move between the reduced profile configuration of FIG. 2 and the expanded configuration of FIGS. 3-4. The use of a pair of slots 46 and 48 reduces the risk of the "button-holing" of the rivet, i.e., a situation in which the opening of the slot becomes distorted and enlarged such that the rivet may slide out of the slot, and cause failure of the device. However, the likelihood of such occurrence is reduced in skirt portion 24 since each of the slots 46 and 48 in the double slot configuration has a relatively shorter length than a single slot configuration, which thereby limits the ability of the respective slots 46 and 48 to be distorted to the extent in which a rivet may slide out of position. In addition, the configuration of rivet 44 and slots 46 and 48 permits a smoother operation of enlarging and reducing the skirt portion 24, and allows the skirt 24 to expand to span as many as three vertebrae, e.g., L4, L5, and S1, to perform a multi-level fixation.

An additional feature of the skirt 24 is the provision of a shallow concave profile 50 defined along the distal edge of the skirt 24, which allows for improved placement of the skirt 24 with respect to the body structures and the surgical instruments defined herein. Small scalloped or notched portions 56 and 58, are provided, as illustrated in FIG. 5. When the skirt 24 is assembled, the cut out portions

56 and 58 are oriented in the ceph-caudad direction (indicated by arrow 60) in FIG. 4 and permit instrumentation, such as an elongated member 650 used in a fixation procedure (described in detail below), to extend beyond the area enclosed by the skirt portion 24 without moving or raising the skirt portion 24 from its location to allow the elongated member 650 to pass under the skirt portion 24. (In another embodiment of the expandable conduit 54 illustrated in FIG. 6, cut out portions 56 and 58 are eliminated from the contour where the physician deems such cut out portions 56 and 58 to be unnecessary in view of the spacing of the fasteners 600 or the length of the elongated member 650.)

10                   As illustrated in FIG. 4, the skirt 24 may be expanded to a substantially conical configuration having a substantially circular or elliptical profile. Alternatively, features may be provided on the skirt which facilitate the bending of the skirt at several locations to provide a pre-formed enlarged configuration. For example, in another embodiment of the expandable conduit 70, illustrated in FIGS. 7-9, skirt portion 74 may have four sections 76a, 76b, 76c, 76d having a reduced thickness. For a skirt portion 74 having a thickness 78 of about .007 inches thick, reduced thickness sections 76a, 76b, 76c, 76d may have a thickness 80 of about 0.002-0.004 inches (FIG. 8). The width 82 of the reduced thickness sections 76a, 76b, 76c, 76d may be about 1-5 mm. The thickness 78 of the skirt portion 74 may be reduced by milling or grinding, as is known in the art. Thus when the skirt 74 is opened, it moves toward a substantially rectangular configuration, subject to the resisting forces of the body tissue (FIG. 9). Alternatively, another embodiment of the skirt (not shown) may be provided with two reduced thickness sections (rather than the four reduced thickness sections of skirt 54) which would produce a substantially “football”-shaped access area.

25                   In another embodiment of the expandable conduit 80, the skirt portion 84 is provided with a plurality of perforations 86, in order to increase flexibility at the desired locations (FIGS. 10-12). The size and number of perforations 86 may vary depending upon the desired flexibility and durability. Alternatively, the skirt may be scored or otherwise provided with a groove or rib in order to facilitate the bending of the skirt at the desired location.

30                   According to still further embodiments, the expandable conduit may be provided with one slot. As illustrated in FIG. 13, skirt portion 94 is provided with slot 96 and aperture 98. A rivet (not shown) is stationary with respect to aperture 98 and

slides within slot 96. Similarly, skirt 104 is provided with an aperture 108 which receives a rivet (not shown) which slides within elongated slot 106 (FIG. 14).

Further details of the expandable conduit are described in U.S. Patent 6,187,00, and in U.S Patent Application no. 09/772,605, filed January 30, 2001, Application no. 09/855,358 filed May 15, 2001, and Application No. 09/630,077 filed August 1, 2000, which are incorporated by reference in their entirety herein.

An early stage in the process is to determine the access point in the skin of the patient to insert the access conduit. In the exemplary embodiment, the access point corresponds to the posterior-lateral aspects of the spine. Manual palpation and Anterior-Posterior (AP) fluoroscopy may be used to determine the optimal incision locations. For the exemplary procedure, placement of the expandable conduit 20 is preferably midway (in the ceph-caud direction) between the L4 through S1 vertebrae, centrally about 4-7 cm from the midline.

An incision is made at the above-determined location. A guide wire (not shown) is introduced under fluoroscopic guidance through the skin, fascia, and muscle to the approximate surgical site. A series of dilators is used to sequentially expand the incision to the desired width, about 23 mm for the exemplary procedure, without damaging the structure of surrounding tissue and muscles. A first dilator is placed over the guide wire, which expands the opening. The guide wire is then subsequently removed. A second dilator that is slightly larger than the first dilator is placed over the first dilator, which expands the opening further. Once the second dilator is in place, the first dilator is subsequently removed. This process of (1) introducing a next-larger-sized dilator coaxially over the previous dilator and (2) subsequently removing the previous dilator when the next-larger-sized dilator is in place continues until an opening of the desired size is created in the skin, muscle, and subcutaneous tissue. In the exemplary method, this dimension is about 23 mm. (Other dimensions of the opening, e.g., about 20 mm, 27 mm, 30 mm, etc., are also useful with this apparatus in connection with spinal surgery, and still other dimensions are contemplated.)

As illustrated in FIG. 15, following placement of the largest dilator 120, the expandable conduit 20, in its reduced profile configuration, is introduced and positioned in a surrounding relationship over the dilator 120. Dilator 120 is subsequently removed from the patient, and the expandable conduit 20 is allowed to remain in position.



Once the expandable conduit 20 is positioned in the patient, it may be enlarged to provide a passage for the insertion of various surgical instrumentation and an enlarged space for performing the procedures described herein. As described above, the expandable conduit may accommodate the enlargement in several ways. In one embodiment, a distal portion of the cannula may be enlarged, and a proximal portion may maintain a constant diameter. The relative lengths of the proximal portion 22 and the skirt portion 24 may be adjusted to vary the overall expansion of the conduit 20. Alternatively, such expansion may extend along the entire length of the expandable conduit. In the exemplary procedure, the expandable conduit 20 may be expanded by removing suture 35 and tearing sleeve 32 surrounding the expandable conduit 20, and subsequently allowing the skirt portion 24 to resiliently expand towards its fully expanded configuration as (illustrated in FIG. 4) to create an enlarged surgical space from the L4 to the S1 vertebrae. The resisting force exerted on the skirt portion may result in the skirt portion 24 assuming the intermediate configuration illustrated in FIG. 3. Under many circumstances, the space created by the skirt portion 24 in the intermediate configuration is a sufficiently large working space to perform the procedure described herein. Once the skirt portion 24 has expanded, the rigidity and resilient characteristics of the skirt portion 24 allow the conduit 20 to resist closing to the reduced profile configuration of FIG. 2 and to at least temporarily resist being expelled from the incision. These characteristics create a stable configuration for the conduit 20 to remain in position in the body, supported by the surrounding tissue. It is understood that additional support may be needed, especially when an endoscope 500 is added.

According to the exemplary embodiment, the expandable conduit 24 may be further enlarged at its distal end portion using an expander apparatus to create a surgical access space. An expander apparatus useful for enlarging the expandable conduit has a reduced profile configuration and an enlarged configuration. The expander apparatus is inserted into the expandable conduit in the reduced profile configuration, and subsequently expanded to the enlarged configuration. The expansion of the expander apparatus also causes the expandable conduit to be expanded to the enlarged configuration. In some embodiments, the expander apparatus may increase the diameter of the expandable conduit along substantially its entire length in a conical configuration. In other embodiments, the expander

apparatus expands only a distal portion of the expandable conduit, allowing a proximal portion to maintain a constant diameter.

In addition to expanding the expandable conduit, the expander apparatus may also be used to position the distal portion of the expandable conduit at the desired location for the surgical procedure. The expander engages the interior wall of the expandable conduit, and moves the cannula to the proper location. For the embodiments in which the distal portion of the expandable conduit is relatively movable with respect to the proximal portion, the expander apparatus is useful to position the distal portion without substantially disturbing the proximal portion.

In the exemplary embodiment, an expander apparatus may be used to further expand the skirt portion 24 towards the fully expanded configuration (illustrated in FIG. 4). The expander apparatus is inserted into the expandable conduit, and typically has two or more members which are movable to engage the interior wall of the skirt portion 24 and apply a force sufficient to further expand the skirt portion 24. An exemplary expander apparatus, expander apparatus 200, is illustrated in FIGS. 16 and 17, and is constructed of two components 202 and 204 defining a tongs-like configuration, and which are pivotable about a pin 206. The components 202 and 204 are typically constructed of steel having a thickness of about 9.7 mm. Each of the components 202 and 204 has a proximal handle portion 208 and a distal expander portion 210. Each proximal handle portion 208 has a finger grip 212 that may extend transversely from the longitudinal axis 214 of the apparatus 200. The proximal handle portion 208 may further include a stop element, such as flange 216, that extends transversely from the longitudinal axis 214, and which is dimensioned to provide a visual and tactile indication of the proper depth for inserting the expander apparatus 200 by engaging the proximal portion 25 of the expandable conduit 20 when the apparatus 200 is inserted a predetermined depth. In the exemplary embodiment, the dimension 218 from the flange 216 to the distal tip 220 is about 106 mm. The dimension 218 is determined by the typical depth of the body structures beneath the skin surface at which the surgical procedure is being performed. The distal portions 210 are each provided with a frusto-conical outer surface 222 for engaging the inside wall of the skirt portion 24. As illustrated in FIG. 16, the unexpanded distal width 224 of the apparatus 200 at the distal tip 220 is about 18.5 mm.

In use, the finger grips 212 are approximated towards one another (arrow A), which causes the distal portions 210 to move to the enlarged configuration (arrows B), illustrated in FIG. 17. The components 202 and 204 are also provided with a cooperating tab 226 and shoulder portion 228 which are configured for mutual engagement when the distal portions 210 are in the expanded configuration. In the exemplary embodiment, the expanded distal width 230 of the distal portions 210 is about 65 mm to about as large as 83 mm. The tab 226 and shoulder configuration 228 limits the expansion of the apparatus 200 in order to prevent expanding the skirt portion 24 of the expandable conduit 20 beyond its designed dimension, and to minimize trauma to the underlying tissue. Further details of the expander apparatus are described in U.S Patent Application No. 09/906,463 filed July 16, 2001, which is incorporated by reference in their entirety herein.

When the expandable conduit 20 is inserted into the patient and sleeve 32 is removed, the skirt portion 24 expands to a point where the outward resilient expansion of the skirt portion 24 is balanced by the force of the surrounding tissue. The surgical space defined by the conduit may be sufficient to perform the surgical procedures. However, if it is desired to expand the expandable conduit 20 further, the expander apparatus 200 may be inserted into the expandable conduit 20 in the reduced profile configuration until the shoulder portions 216 are in approximation with the proximal lip 25 of the cylindrical portion 24 of the expandable conduit 20 (FIG. 18).

As illustrated in FIG. 18, the expander apparatus 200 is inserted in the access conduit 20 in the reduced profiled configuration. Expansion of apparatus 200 is achieved by approximating the handle portions 212 (not shown in FIG. 18), which causes the distal portions 210 of the expander apparatus 200 to move to a spaced apart configuration. As the distal portions 210 move apart and contact the inner wall of the skirt portion 24, it is expanded by allowing the floating rivet 44 to slide within the two slots 46 and 48 of the skirt portion 24. When the distal portions 210 reach the maximum expansion of the skirt portion 24 (illustrated by a dashed line), the shoulder 228 and tab portion 226 of the expander apparatus 200 come into engagement to prevent further expansion of the skirt portions (as illustrated in FIG. 17). The conduit 20 may be alternatively further expanded with a balloon or similar device.

A subsequent, optional step in the procedure is to adjust the location of the distal portion of the expandable conduit relative to the body structures to be operated on. For example, the expander apparatus 200 may also be used to engage

the inner wall of the skirt portion 24 of the expandable conduit 20 in order to move the skirt portion 24 of the expandable conduit 20 to the desired location. For an embodiment in which the skirt portion 24 of the expandable conduit 20 is relatively movable relative to the proximal portion, e.g. by use of the rivet 30, the expander apparatus 200 is useful to position the skirt portion 24 without substantially disturbing the proximal portion 22 or the tissues closer to the skin surface of the patient. As will be described below, the ability to move the distal end portion, e.g., the skirt portion, without disturbing the proximal portion is especially beneficial when additional apparatus, as described below, is mounted relative to the proximal portion of the expandable conduit.

An endoscope mount platform 300 and indexing arm 400 provide securement of an endoscope 500 on the proximal portion 25 of access conduit 20 for remotely viewing the surgical procedure, as illustrated in FIGS. 20-23. The endoscope mount platform 300 also provides several functions during the surgical procedure. The endoscope mount platform 300 includes a base 302 that extends laterally from a central opening 304 in a general ring-shaped configuration. For the physician who is primarily viewing the procedure by observing a monitor, the base 302 provides an aid for the physician when inserting surgical instruments into the central opening 304. For example, the size of the base 302 provides visual assistance (as it may be observable in the physician's peripheral vision) as well as provides tactile feedback as the instruments are lowered towards the central opening 304 and into the expandable conduit 20.

The endoscope mount platform 300 further provides a guide portion 306, which extends substantially parallel to the longitudinal axis 308 away from the central opening 304. The base 302 is typically molded as one piece with the guide portion 306. The base 302 and guide portion 306 may be constructed as a suitable polymer such as polyetheretherketone (PEEK).

The guide portion 306 includes a first upright member 310 extending upward from the base 302, and a second upright member 312 extending upward from the base 302. The upright members 310 and 312 each have a respective vertical grooves 314 and 315 for slidably receiving an endoscopic mount assembly 318.

The endoscope 500 (not shown in FIG. 20) is movably mounted to the endoscope mount platform 300 by the endoscope mount assembly 318 including endoscope mount 320 and a saddle unit 322. The saddle unit 322 is slidably mounted

within the grooves 314 and 315 in the upright members 310 and 312. The endoscope mount 320 receives the endoscope 500 through a bore 326 which passes through the endoscope mount 320. Part of the endoscope 500 may extend through the expandable conduit 20 substantially parallel to central axis 308 into the patient's body 130.

5           The endoscope mount 320 is removably positioned in a recess 328 defined in the substantially "U"-shaped saddle unit 322, which is selectively movable in a direction parallel to the longitudinal axis 308 in order to position the endoscope 500 at the desired height within the expandable conduit 20 to provide a zoom feature to physician's view of the surgical procedure.

10           A screw mechanism 340 is positioned on the base 302 and between the upright members 310 and 312, and is used to selectively move the saddle unit 322 with the endoscope mount 320 and the endoscope 500. The screw mechanism 340 comprises a thumb wheel 342 and a spindle 344. The thumb wheel 342 is rotatably mounted in a bore in the base 302. The thumbwheel has an external thread 346  
15       received in a cooperating thread in the base 302. The spindle 344 is mounted for movement substantially parallel to the central axis 308. The spindle 344 has a first end received in a rectangular opening in the saddle unit 322, which inhibits rotational movement of the spindle unit 344. The second end of the spindle 344 has an external thread which cooperates with an internal thread formed in a bore within the  
20       thumbwheel 342. Rotation of the thumb wheel 342 relative to the spindle 344, causes relative axial movement of the spindle unit 344 along with the saddle unit 322. Further details of the endoscope mount platform are described in U.S. Patent Application No. 09/491,808 filed January 28, 2000, Application No. 09/821,297 filed March 29, 2001, and Application 09/940,402 filed August 27, 2001.

25           As illustrated in FIG. 21-23, the endoscope mount platform 300 is mounted to the support arm 400. The support arm 400, in turn, is mounted to mechanical support, such as mechanical support arm A, which is incorporated by reference in its entirety herein. The support arm 400 rests on the proximal portion 25 of the expandable conduit 20. The support arm 400 includes an indexing collar 420, which is received in the central opening 304 of the base 302 of endoscope mount  
30       platform 300. The indexing collar 420 is substantially toroidal in section and has an outer peripheral wall 422 and inner wall 424 and a wall thickness 426. The indexing collar further includes a flange 428, which supports the indexing collar 420 on the support arm 400.

In order to support conduits 20 of different dimensions, a plurality of indexing collars 420 may be provided to accommodate each respective conduit size while using a single endoscope mount platform 300. The central opening 304 of the endoscope mount platform 300 has constant dimension, e.g., a diameter of about 32.6 mm. An appropriate indexing collar 420 is selected to support the respective conduit 20. Thus the outer wall 422 and the outer diameter 430 are unchanged between different indexing collars 420, although the inner wall 424 and the inner diameter 432 vary to accommodate differently sized conduits 20.

The indexing collar 420 is mounted to the proximal portion of the expandable conduit 20 and allows angular movement of the endoscope mount platform 300 with respect thereto about the central axis 308 (as indicated by arrow C in FIG. 21). The outer wall 422 of the index collar 420 includes a plurality of hemispherical recesses 450 for receiving one or more ball plungers 350 on the endoscope mount platform 300 (indicated in dashed line.) This mount configuration permits the endoscope mount platform 300, along with the endoscope 500 to be fixed in a plurality of discrete angular positions. Further details of the support arm and indexing collar are described in U.S Patent Application No. 09/491,808 filed January 28, 2000, Application No. 09/821,297 filed March 29, 2001, and Application 09/940,402 filed August 27, 2001.

The endoscope, such as endoscope 500 (FIG. 24), has an elongated configuration that extends into the expandable conduit 20 in order to view the surgical site. In particular, endoscope 500 has an elongated rod portion 502 and a body portion 504 which is substantially perpendicular thereto. In the exemplary embodiment, rod portion 502 of endoscope 500 has a diameter of about 4 mm and a length of about 106 mm. Body portion 504 may define a tubular portion 506 which is configured to be slidably received in the bore 326 of endoscope mount 320 as indicated by arrow D. The slidable mount of the endoscope 500 on the endoscope mount 300 permits the endoscope 500 to adjust to configurations that incorporate different conduit diameters. Additional mobility of the endoscope 500 in viewing the surgical site may be provided by rotating the endoscope mount platform 300 about the central axis 308 (as indicated by arrow C in FIG. 21).

The rod portion 502 supports an optical portion (not shown) at a distal end 508 thereof, which may define a field of view of about 105 degrees and a direction of view 511 of about 25-30 degrees. An eyepiece 512 is positioned at an

end portion of the body portion 504. The camera (not shown) is attached to the endoscope 500 adjacent the eyepiece 512 with a standard coupler unit. A light post 510 supplies illumination to the surgical site at the distal end portion 508. A preferred camera for use in the system and procedures described herein is a three chip unit that provides greater resolution to the viewed image than a single chip device.

A subsequent stage in the procedure is the placement of the support arm 400 and the endoscope mount platform 300 on the proximal portion 28 of the expandable conduit 20 (FIG. 1 and 22), and mounting of the endoscope 500 on the endoscope mount platform 300. A next step is insertion of surgical instrumentation in to the expandable conduit to perform the surgical procedure on the body structures at least partially within the operative space defined by the expanded portion of the expandable conduit. In the exemplary method, skirt portion 24 of expandable conduit 20 at least partially defines operative space 90 in which the surgical procedures described herein may be performed (FIG. 25). Depending upon the overlap of the skirt portion, the skirt portion may define a surface which is continuous about the circumference or which is discontinuous having one or more gaps where the material of the skirt portion does not overlap. For illustrative purposes, the surgical instrumentation described herein is useful to perform a two-level spinal fixation. Surgical instrumentation inserted into the expandable conduit is used for debridement and decortication. In particular, the soft tissue, such as fat and muscle, covering the vertebrae are removed in order to allow the physician to visually identify the various "landmarks," or vertebral structures, which enable the physician to locate the location for attaching the fasteners 600 or other procedures, as will be described herein. Allowing visual identification of the vertebral structures enables the physician to perform the procedure while viewing the surgical area through the endoscope, microscope, loupes, etc., or in a conventional, open manner.

Tissue debridement and decortication of bone are completed using one or more debrider blades, bipolar sheath, high speed burr, and additional conventional manual instruments. The debrider blades are used to excise, remove and aspirate the soft tissue. The bipolar sheath is used to achieve hemostasis through spot and bulk tissue coagulation. The debrider blades and bipolar sheath are described in greater detail in U.S. Patent No. 6,193,715, assigned to Medical Scientific, Inc., which is incorporated by reference in their entirety herein. The high speed burr and

conventional manual instruments are also used to continue to expose the structure of the vertebrae.

A subsequent stage is the attachment of fasteners to the vertebrae V. Prior to attachment of the fasteners, the location of the fastener attachment is confirmed. In the exemplary embodiment, the pedicle entry point of the L5 vertebrae is located using visual landmarks as well as lateral and A/P fluoroscopy, as is known in the art. With continued reference to FIG. 25, the entry point 92 is prepared with an awl 550. The pedicle hole 92 is completed using instruments known in the art such as a straight bone probe, a tap, and a sounder. The sounder, as is known in the art, determines whether the hole that is made is surrounded by bone on all sides, and that there has been no perforation of the pedicle wall.

After hole 92 in the pedicle is provided (or at any point during the procedure), an optional step is to adjust the location of the distal portion of the expandable conduit. This may be performed by inserting the expander apparatus 200 into the expandable conduit 20, expanding the distal portions 210, and contacting the inner wall of the skirt portion 24 to move the skirt portion 24 to the desired location. This step may be performed while the endoscope 500 is positioned within the expandable conduit 20, and without substantially disturbing the location of the proximal portion of the expandable conduit 20 to which the endoscope mount platform 300 may be attached.

A particularly useful fastener for use in the exemplary procedure is the fastener 600, illustrated in FIGS. 26-27, and described in greater detail in U.S. Patent application No. 10/075,668, filed February 13, 2002 and application No. 10/087,489, filed March 1, 2002, which are incorporated by reference in its entirety herein. Fastener 600 includes a screw portion 602, a housing 604, a spacer member 606, a biasing member 608, and a clamping member, such as cap screw 610. The screw portion 602 has a distal threaded portion 612 and a proximal, substantially spherical joint portion 614. The threaded portion 612 is inserted into the hole 92 in the vertebrae, as will be described below. The substantially spherical joint portion 614 is received in a substantially annular, part spherical recess 616 in the housing 604 in a ball and socket joint relationship (see also FIG. 29).

As illustrated in FIG. 27, the fastener is assembled by inserting the screw portion 602 into a bore in a passage 618 in the housing 604, until the joint portion 614 engages the annular recess 616. The screw portion 602 is retained in the



housing 604 by the spacer member 606 and biasing member 608. The biasing member 608 provides a biasing force to drive the spacer member 606 in frictional engagement with the joint portion 614 of the screw member 602 and the annular recess 616 of the housing 604. The biasing provided by the biasing member 602  
5 frictionally maintains the relative positioning of the housing 604 with respect to the screw portion 602. The biasing member 608 is selected such that biasing force prevents unrestricted movement of the housing 604 relative to the screw portion 602. However, the biasing force is insufficient to resist the application of force by a physician to move the housing 604 relative to the screw portion 602. In other words,  
10 this biasing force is strong enough maintain the housing 604 stationary relative to the screw portion 602, but this force may be overcome by the physician to reorient the housing 604 with respect to the screw member 602, as will be described below.

In the exemplary embodiment, the biasing member 608 is a resilient ring having a gap 620, which permits the biasing member 608 to radially contract and  
15 expand. The biasing member 608 has an arched shape, when viewed end-on (FIG. 27(a)). The arch shape of the spring member 608 provides the biasing force, as will be described below. The spacer member 606 and the biasing member 608 are inserted into the housing 604 by radially compressing the biasing member into an annular groove 622 in the spacer member 606. The spacer member 606 and the biasing  
20 member 608 are slid into the passage 618 until the distal surface of the spacer member 606 engages the joint portion 614 of the screw portion 602, and the biasing member 608 expands radially into the annular groove 620 in the housing 604. The annular groove 620 in the housing 604 has a dimension 623 which is smaller than the uncompressed height of the arched shape of the biasing member 608. When the  
25 biasing member 608 is inserted in the annular groove 620, the biasing member 608 is flattened against its normal bias, thereby exerting the biasing force to the spacer member 606. It is understood that similar biasing members, such as coiled springs, belleville washers, or the like may be used to supply the biasing force described herein.

30 The spacer member 606 is provided with a longitudinal bore 626, which provides access to a hexagonal recess 628 in the proximal end of the joint portion 614 of the screw member 602. The proximal portion of the housing 604 includes a pair of upright members 630 and 631 that are separated by substantially "U"-shaped grooves 632. A recess for receiving elongated member 650 is defined by

the pair of grooves 632 between upright member 630 and 631. Elongated member 650 to be placed distally into the housing 604 in an orientation substantially transverse to the longitudinal axis of the housing 604, as will be described below. The inner walls of the upright members 630 and 631 are provided with threads 634  
5 for attachment of the cap screw 610 by threads 613 therein.

The fastener 600 is inserted into the expandable conduit 20 and guided to the prepared hole 92 in the vertebrae as a further stage of the procedure. The fastener 600 must be simultaneously supported and rotated in order to be secured in hole 92. In the exemplary embodiment, the fastener 600 is supported and attached to  
10 the bone by an endoscopic screwdriver apparatus 660, illustrated in FIGS. 28 - 29. Screwdriver 660 includes a proximal handle portion 662 (illustrated in dashed line), an elongated body portion 664, and a distal tool portion 666.

The distal tool portion 666, as illustrated in greater detail in FIG. 29 includes a substantially hexagonal outer periphery which is received in the  
15 substantially hexagonal recess 628 in the joint portion 614 of the screw member 602. A spring member at the distal tool portion 666 releasably engages the hexagonal recess 628 of the screw member 602 to support the fastener 600 during insertion and tightening. In the exemplary embodiment, a spring member 672 is configured to engage the side wall of the recess 628. More particularly, a channel/groove is  
20 provided in the tip portion 666 for receiving the spring member 672. The channel/groove includes a medial longitudinal notch portion 676, a proximal, angled channel portion 678, and a distal substantially transverse channel portion 680. The spring member 672 is preferably manufactured from stainless steel and has a medial portion 682 which is partially received in the longitudinal notch portion 676, an  
25 angled proximal portion 684 which is fixedly received in the angled channel portion 678, and a transverse distal portion 686 which is slidably received in the transverse channel 680. The medial portion 682 of the spring member 672 is partially exposed from the distal tip portion 666 and normally biased in a transverse outward direction with respect to the longitudinal axis (indicated by arrow E), in order to supply bearing  
30 force against the wall of the recess 628. Alternatively, the distal tip portion of the screw driver may be magnetized in order to hold the screw portion 602. Similarly, the distal tip portion may include a ball bearing or similar member which is normally biased in a radially outward direction to engage the interior wall of the recess 628 to secure the fastener 600 to the screwdriver distal tip 666.

The insertion of the fastener 600 into the prepared hole 92 may be achieved by insertion of screwdriver 660 into conduit 20 (indicated by arrow G). This procedure may be visualized by the use of the endoscope 500 in conjunction with fluoroscopy. The screw portion 602 is threaded into the prepared hole 92 by the  
5 endoscopic screwdriver 660 (indicated by arrow H). The endoscopic screwdriver 660 is subsequently separated from the screw, by applying a force in the proximal direction, and thereby releasing the distal tip portion 666 from the hexagonal recess 628 (e.g., causing the transverse distal portion 686 of the spring member 672 to slide within the transverse recess 680 against the bias, indicated by arrow F), and removing  
10 the screwdriver 660 from the expandable conduit 20. An alternative method may use a guidewire, which is fixed in the hole 92, and a cannulated screw which has an internal lumen (as is known in the art) and is guided over the guidewire into the hole 92. The screwdriver would be cannulated as well to fit over the guidewire.

For a two-level fixation, it may be necessary to prepare several holes  
15 and attach several fasteners 600. Typically, the expandable conduit will be sized in order to provide simultaneous access to all vertebrae in which the surgical procedure is being performed. In some cases, however, additional enlargement or repositioning of the distal portion of the expandable conduit may be required in order to have sufficient access to the outer vertebrae, e.g., the L4 and S1 vertebrae. In the  
20 exemplary embodiment, the expander apparatus 200 may be repeatedly inserted into the expandable conduit 20 and expanded in order to further open or position the skirt portion 24. In the exemplary procedure, additional fasteners are inserted in the L4 and S1 vertebrae in a similar fashion as the fastener 600 inserted in to the L5 vertebra as described above. (When discussed individually or collectively, a fastener and/or its  
25 individual components will be referred to by the reference number, e.g., fastener 600, housing 604, and all fasteners 600. However, when several fasteners and/or their components are discussed in relation to one another, an alphabetic subscript will be used, e.g., fastener 600a is moved towards fastener 600b.)

In a further stage of the procedure, the housing portions 604 of the  
30 fasteners 600 are substantially aligned such that their upright portions 630 and 631 face upward, and the notches 632 are substantially aligned to receive the elongated member 650 therein. The frictional mounting of the housing 604 to the screw member 602, described above, allows the housing 604 to be temporarily positioned until a subsequent tightening step, described below. Positioning of the housing

portions 604 may be performed by the use of an elongated surgical instrument capable of contacting and moving the housing portion to the desired orientation. An exemplary instrument for positioning the housings 604 is a grasper apparatus 700, illustrated in FIG. 30. The grasper apparatus 700 includes a proximal handle portion 5 702, an elongated body portion 704, and distal nose portion 706. The distal nose portion 706 includes a pair of grasping jaws 708a and 708b, which are pivotable about pin 710 by actuation of the proximal handle portion 702. The grasping jaws 708a and 708b are illustrated in the closed position in FIG. 30. As is known in the art, pivoting the movable handle 714 towards stationary handle 714 causes longitudinal movement 10 of actuator 716, which in turn pivots the jaw 708b towards an open position (illustrated in dashed line). The biasing members 718 and 720 are provided to return the handles 712 and 714 to the open position and bias the jaws 708a and 708b to the closed position.

A subsequent stage in the process is the insertion of the elongated 15 member 650 into the expandable conduit. The elongated member is manufactured from a biocompatible material and must be sufficiently strong to maintain the positioning of the vertebrae, or other body structures. In the exemplary embodiment, the elongated members 650 are manufactured from Titanium 6/4 or titanium alloy. Alternatively, the elongated member may be manufactured from stainless steel or 20 other suitable material. The radii and length of the elongated members 650 are selected by the physician to provide the best fit for the positioning of the screw heads. Such selection may be performed by placing the elongated member 650 on the skin of the patient overlying the location of the fasteners and viewed fluoroscopically. For example, a 70 mm preformed rod having a 3.5" bend radius may be selected for the 25 spinal fixation.

The elongated member 650 is subsequently fixed to each of the fasteners 600, and more particularly, to the housings 604 of each fastener. The grasper apparatus 700, described above, is also particularly useful for inserting the elongated member 650 into the expandable conduit 20 and positioning it with respect 30 to each housing 604. As illustrated in FIG. 30, the jaws 708a and 708b of the grasper apparatus 700 each has a curved contact portion 722a and 722b for contacting and holding the outer surface of the elongated member 650.

As illustrated in FIG. 31, the grasper apparatus 700 may be used to insert the elongated member 650 into the operative space 90 defined at least partially

by the skirt portion 24 of the expandable conduit 20. The cut-out portions 56 and 58 provided in the skirt portion 24 assist in the process of installing the elongated member 650 with respect to the housings 604. The cut-out portions 56 and 58 allow an end portion 652 of the elongated member 650 to extend beyond the operative space without raising or repositioning the skirt portion 24. The elongated member 650 is positioned within the recesses in each housing 604 defined by grooves 632 disposed between upright members 630 and 631. The elongated member 650 is positioned in an orientation substantially transverse to the longitudinal axis of each housing 604.

Further positioning of the elongated member 650 may be performed by guide apparatus 800, illustrated in FIG. 32. Guide apparatus 800 is useful in cooperation with an endoscopic screwdriver, such as endoscopic screwdriver 660 (illustrated in FIG. 28), in order to position the elongated member 650, and to introduce and tighten the cap screw 610, described above and illustrated in FIG. 27. Tightening of the cap screw 610 with respect to the housing 604 fixes the orientation of the housing 604 with respect to the screw portion 602 and fixes the position of the elongated member 650 with respect to the housing 604.

In the exemplary embodiment, the guide apparatus 800 has a proximal handle portion 802, an elongated body portion 804, and a distal tool portion 806. The elongated body portion 804 defines a central bore 808 (illustrated in dashed line) along its longitudinal axis 810. The central bore 808 is sized and configured to receive the endoscopic screwdriver 660 and cap screw 610 therethrough. In the exemplary embodiment, the diameter of the central bore 808 of the elongated body portion 804 is about 0.384 – 0.388 inches in diameter, and the external diameter of the endoscopic screwdriver 660 (FIG. 28) is about 0.25 inches. The proximal handle portion 802 extends transverse to the longitudinal axis 810, which allows the physician to adjust the guide apparatus 800 without interfering with the operation of the screwdriver 660.

The distal portion 806 of the apparatus includes several semicircular cut out portions 814 which assist in positioning the elongated member 650. As illustrated in FIG. 33, the cut out portions 814 are sized and configured to engage the surface of elongated member 650 and move the elongated member 650 from an initial location (illustrated in dashed line) to a desired location.

As illustrated in FIG. 34, the guide apparatus 800 is used in cooperation with the endoscopic screwdriver 660 to attach the cap screw 610. The

distal end of the body portion 804 includes a pair of elongated openings 816, which permit the physician to endoscopically view the cap screw 610 retained at the distal tip 666 of the endoscopic screw driver 660.

The guide apparatus 800 and the endoscopic screwdriver 660 may cooperate as follows: The guide apparatus 800 is configured to be positioned in a surrounding configuration with the screwdriver 600. In the exemplary embodiment, the body portion 804 is configured for coaxial placement about the screwdriver 660 in order to distribute the contact force of the guide apparatus 800 on the elongated member 650. The distal portion 806 of the guide apparatus 800 may bear down on the elongated member 650 to seat the elongated member 650 in the notches 632 in the housing 604. The “distributed” force of the guide apparatus 800 may contact the elongated member 650 on at least one or more locations. In addition, the diameter of central bore 808 is selected to be marginally larger than the exterior diameter of cap screw 610, such that the cap screw 610 may freely slide down the central bore 808, while maintaining the orientation shown in FIG. 34. This configuration allows the physician to have effective control of the placement of the cap screw 610 into the housing 604. The cap screw 610 is releasably attached to the endoscopic screwdriver 660 by means of spring member 672 engaged to the interior wall of hexagonal recess 611 as it is inserted within the bore 808 of the body portion 804 of guide apparatus 800. The cap screw 610 is attached to the housing 604 by engaging the threads 615 of the cap screw 610 with the threads 634 of the housing.

As illustrated in FIG. 35, tightening of the cap screw 610 fixes the assembly of the housing 604 with respect to the elongated member 650. In particular, the distal surface of the cap screw 610 provides a distal force against the elongated member 650, which in turn drives the spacer member 606 against the joint portion 614 of the screw portion 602, which is consequently fixed with respect to the housing 604.

If locations of the vertebrae are considered acceptable by the physician, then the fixation procedure is substantially complete once the cap screws 610 have been attached to the respective housings 604, and tightened to provide a fixed structure as between the elongated member 650 and the various fasteners 600. However, if compression or distraction of the vertebrae with respect to one another is required additional apparatus would be used to shift the vertebrae prior to final tightening all of the cap screws 610.

In the exemplary embodiment, this step is performed with a surgical instrument, such as compressor-distractor instrument 900, illustrated in FIG. 36, which is useful to relatively position bone structures in the ceph-caud direction and to fix their position with respect to one another. Thus, the compressor-distractor instrument 900 has the capability to engage two fasteners 600 and to space them apart while simultaneously tightening one of the fasteners to fix the spacing between the two vertebrae, or other bone structures. Moreover, the compressor-distractor instrument 900 may also be used to move two fasteners 600, and the vertebrae attached thereto into closer approximation and fix the spacing therebetween.

The distal tool portion 902 of the compressor-distractor instrument 900 is illustrated in FIG. 36. (Further details of the compressor-distractor apparatus is described in co-pending U.S. application No. 10/178,875, filed June 24, 2002, entitled "Surgical Instrument for Moving Vertebrae," which is incorporated by reference in its entirety herein.) The distal tool portion 902 includes a driver portion 904 and a spacing member 906. The driver portion 904 has a distal end portion 908 with a plurality of wrenching flats configured to engage the recess 611 in the proximal face of the cap screw 610, and to apply torque to the cap screw. The driver portion 904 is rotatable about the longitudinal axis (indicated by arrow M) to rotate the cap screw 610 relative to the fastener 600. Accordingly, the driver portion 904 can be rotated to loosen the cap screw 610 on the fastener 600 and permit movement of the elongated member 650 connected with the vertebra relative to the fastener 600 connected with the vertebra. The cap screw 610 can also be rotated in order to tighten the cap screw 610 and clamp the elongated member 650 to the fastener 600.

The distal tool portion 902 may also include a spacing member, such as spacing member 906, which engages an adjacent fastener 600b while driver member 904 is engaged with housing 600a to move the fastener 600b with respect to fastener 600a. In the exemplary embodiment, spacing member 906 is a jaw portion which is pivotably mounted to move between a first position adjacent the driver portion and a second position spaced from the driver portion, as shown in FIG. 36. The distal tip 910 of the spacing member 906 is movable relative to the driver portion 904 in a direction extending transverse to the longitudinal axis.

As illustrated in FIG. 36, the spacer member 906 can be opened with respect to the driver portion 904 to space the vertebrae further apart (as indicated by arrow N). The distal portion 910 of the spacer member 906 engages the housing 604b

of fastener 600b and moves fastener 600b further apart from fastener 600a to distract the vertebrae. Where the vertebrae are to be moved closer together, e.g. compressed, the spacer member 906 is closed with respect to the driver portion 904 (arrow P), as illustrated in FIG. 37. The distal portion 610 of spacer member 606 engages housing 604b of fastener 600b and moves fastener 600b towards fastener 600a. When the spacing of the vertebrae is acceptable to the physician, the cap screw 610a is tightened by the driver member 904, thereby fixing the relationship of the housing 604a with respect to elongated member 650, and thereby fixing the position of the vertebrae, or other bone structures, with respect to one another.

Once the elongated member 650 is fixed with respect to the fasteners 600, the procedure is substantially complete. The surgical instrumentation, such as the endoscope 500 is withdrawn from the surgical site. The expandable conduit 20 is also withdrawn from the site. The muscle and fascia typically close as the expandable conduit 20 is withdrawn through the dilated tissues in the reduced profile configuration. The fascia and skin incisions are closed in the typical manner, with sutures, etc. The procedure described above may be repeated for the other lateral side of the same vertebrae, if indicated.

It will be understood that the foregoing is only illustrative of the principles of the invention, and that various modifications can be made by those skilled in the art without departing from the scope and spirit of the invention.



## CLAIMS

What is claimed is:

1. A system for performing surgical procedures on bone structures located beneath body tissue in a patient, comprising:

5 (a) an expandable conduit comprising a wall portion defining an internal passage therethrough and a first configuration having a first cross-sectional area at a distal portion thereof for percutaneous insertion into said body tissue, said wall portion movable against said body tissue to define a second configuration having an enlarged cross-sectional area at said distal portion thereof;

10 (b) an elongated member configured for insertion into said internal passage of said expandable conduit;

(c) a first fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a first bone portion, the first fastener defining a first recess for receiving a portion of said elongated member  
15 therein, said first fastener comprising a first clamping member attachable to said first fastener to clamp said elongated member and first fastener into fixed engagement;

(d) a second fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a second bone portion, the second fastener defining a second recess for receiving a portion of said elongated  
20 member therein, said second fastener comprising a second clamping member attachable to said second fastener to clamp said elongated member and second fastener into fixed engagement; and

(e) a driver member configured for insertion into said internal passage of said expandable conduit to secure said first and second clamping members  
25 to said respective first and second fasteners.

2. The system of claim 1, wherein the first bone portion is a first vertebra, and the second bone portion is a second vertebra.

3. The system of claim 1, wherein said wall portion of said expandable conduit is configured to be at least partially supported in said body tissue in said  
30 second configuration.

4. The system of claim 1, wherein said wall portion of said expandable conduit comprises a flexible sheet defining a first overlapping configuration in said first configuration and a second overlapping configuration in said second configuration.

5. The system of claim 4, wherein said wall portion comprises a first and second cooperating slot and a pin slidable within said first and second cooperating slots to allow said wall portion to move between said first configuration and said second configuration.

5 6. The system of claim 4, wherein said wall portion of said expandable conduit is configured to resiliently expand from said first configuration to said second configuration.

7. The system of claim 1, wherein said wall portion of said expandable conduit comprises a distal wall portion movable about a longitudinal axis thereof  
10 relative to a proximal wall portion.

8. The system of claim 7, wherein said distal wall portion of said expandable conduit is pivotably mounted with respect to said proximal wall portion.

9. The system of claim 1, wherein said wall portion of said expandable conduit defines a notch at a distal portion thereof configured to allow a portion of said  
15 elongated member to pass therethrough.

10. The system of claim 1, wherein said wall portion defines a plurality of elongated reduced thickness portions configured to allow said wall portion to bend along said elongated reduced thickness portion when said wall portion is expanded from said first configuration to said second configuration.

20 11. The system of claim 1, wherein said wall portion defines a plurality of perforations oriented in a substantially linear arrangement configured to allow said wall portion to bend along said plurality of perforations when said wall portion is expanded from said first configuration to said second configuration.

12. The system of claim 1, further comprising an expansion instrument  
25 having a remotely actuatable distal portion movable between an approximated configuration and a spaced apart configuration, said expansion instrument configured for insertion into said internal passage of said expandable conduit in said approximated configuration and expandable to said spaced apart configuration to expand said cross-sectional area defined by said wall portion thereof.

30 13. The system of claim 12, wherein said expansion instrument comprises a stop configured to engage a proximal portion of said expandable conduit to limit insertion of said expansion instrument into said internal passage of said expandable conduit.

14. The system of claim 12, wherein said expansion instrument comprises a pair of pivotable members for engaging said wall portion of said expandable conduit and a cooperating tab and shoulder portion associated with said pivotable members to limit expansion of said pivotable members.

5 15. The system of claim 1, wherein said first fastener further comprises a first housing defining a longitudinal axis and said first recess is defined in said first housing to receive said elongated member in an orientation substantially transverse to said longitudinal axis of said first housing.

10 16. The system of claim 15, wherein said first recess is defined by a pair of notches disposed between a pair of upright members in said first housing.

17. The system of claim 16, wherein an inner surface of said upright members defines a series of threads cooperative with a series of threads defined on said first clamping member.

15 18. The system of claim 1, the first fastener comprises a first screw portion for fixation to the first bone portion, a first housing movably mounted with respect to said first screw portion and defining said first recess for receiving said elongated member therein, and a first biasing member mounted in said first housing to apply a biasing force to drive a first spacer member into frictional engagement with said first screw member to restrict movement of said first housing with respect to said first  
20 screw portion.

19. The system of claim 18, wherein said first biasing member is selected such that said biasing force applied thereby to drive said first spacer member into frictional engagement with said first screw member is insufficient to resist application of a predetermined force applied by a user to move of said first housing with respect  
25 to said first screw member.

20. The system of claim 1, wherein said driver member is rotatable about said longitudinal axis to secure said first clamping member to said first fastener.

21. The system of claim 1, further comprising a pusher member configured to urge said elongated member in said first recess in said first fastener.

30 22. The system of claim 21, wherein the pusher member comprises a tubular member defining an internal lumen configured for coaxial positioning about said driver member.

23. The system of claim 21, wherein the pusher member comprises an internal lumen configured to guide said first clamping member to said first fastener.

24. The system of claim 1, further comprising an adjustment apparatus configured for insertion into said internal passage of said expandable conduit comprising a spacing member for applying a force to said second fastener to move said second bone portion with respect to said first bone portion.

5 25. The system of claim 24, wherein said adjustment apparatus further comprises a second driver member cooperative with said spacing member for securing said first clamping member with respect to said first fastener.

26. The system of claim 24, wherein the spacing member is pivotably mounted for movement between a first position adjacent said second driver member and a second position spaced apart from said second driver member.

27. The system of claim 1, further comprising an apparatus for supporting an endoscope comprising a base portion defining a bore in communication with said internal passage of said expandable conduit, and an endoscope mounting member movably mounted with respect to said base for supporting an endoscope within said internal passage of said expandable cannula.

28. The system of claim 27, wherein said base portion is rotatable about a longitudinal axis of said expandable conduit.

29. The system of claim 27, wherein said endoscope mounting member comprises a screw member positioned between said base and said endoscope mounting member to provide movement of said endoscope relative to said base in said longitudinal axis.

30. The system of claim 27, wherein said endoscope mounting member is movable with respect to said base in a direction substantially transverse to said longitudinal axis.

25 31. A system for performing surgical procedures on bone structures located beneath body tissue in a patient, comprising:

(a) an expandable conduit comprising a wall portion defining an internal passage therethrough and a first configuration having a first cross-sectional area at a distal portion thereof for percutaneous insertion into said body tissue, said wall portion movable against said body tissue to define a second configuration having an enlarged cross-sectional area at said distal portion thereof;

(b) an elongated member configured for insertion into said internal passage of said expandable conduit;

(c) a first fastener configured for insertion into said internal

passage of said expandable conduit and for fixation to a first bone portion, the first fastener defining a first recess for receiving a portion of said elongated member therein, said first fastener comprising a first clamping member attachable to said first fastener to clamp said elongated member and first fastener into fixed engagement;

5                   (d)       a second fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a second bone portion, the second fastener defining a second recess for receiving a portion of said elongated member therein, said second fastener comprising a second clamping member attachable to said second fastener to clamp said elongated member and second  
10 fastener into fixed engagement;

                  (e)       a third fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a third bone portion, the third fastener defining a third recess for receiving a portion of said elongated member therein, said third fastener comprising a third clamping member attachable to said  
15 third fastener to clamp said elongated member and third fastener into fixed engagement; and

                  (f)       a driver member configured for insertion into said internal passage of said expandable conduit to secure at least one of said first, second, and third clamping members to said respective first, second, and third fasteners.

20           32.       The system of claim 31, wherein the first bone portion is a first vertebra, the second bone portion is a second vertebra, and the third bone portion is a third vertebra.

                  33.       The system of claim 31, wherein said wall portion of said expandable conduit is configured to be at least partially supported in said body tissue in said  
25 second configuration.

                  34.       The system of claim 31, wherein said wall portion of said expandable conduit comprises a flexible sheet defining a first overlapping configuration in said first configuration and a second overlapping configuration in said second configuration.

30           35.       The system of claim 34, wherein said wall portion comprises a first and second cooperating slot and a pin slidable within said first and second cooperating slots to allow said wall portion to move between said first configuration and said second configuration.

36. The system of claim 34, wherein said wall portion of said expandable conduit is configured to resiliently expand from said first configuration to said second configuration.

37. The system of claim 31, wherein said wall portion of said expandable  
5 conduit comprises a distal wall portion movable about a longitudinal axis thereof relative to a proximal wall portion.

38. The system of claim 37, wherein said distal wall portion of said expandable conduit is pivotably mounted with respect to said proximal wall portion.

39. The system of claim 31, wherein said wall portion of said expandable  
10 conduit defines a notch at a distal portion thereof configured to allow a portion of said elongated member to pass therethrough.

40. The system of claim 31, wherein said wall portion defines a plurality of elongated reduced thickness portions configured to allow said wall portion to bend along said elongated reduced thickness portion when said wall portion is expanded  
15 from said first configuration to said second configuration.

41. The system of claim 31, wherein said wall portion defines a plurality of perforations oriented in a substantially linear arrangement configured to allow said wall portion to bend along said plurality of perforations when said wall portion is expanded from said first configuration to said second configuration.

42. The system of claim 31, further comprising an expansion instrument  
20 having a remotely actuatable distal portion movable between an approximated configuration and a spaced apart configuration, said expansion instrument configured for insertion into said internal passage of said expandable conduit in said approximated configuration and expandable to said spaced apart configuration to  
25 expand said cross-sectional area defined by said wall portion thereof.

43. The system of claim 42, wherein said expansion instrument comprises a stop configured to engage a proximal portion of said expandable conduit to limit insertion of said expansion instrument into said internal passage of said expandable conduit.

44. The system of claim 42, wherein said expansion instrument comprises  
30 a pair of pivotable members for engaging said wall portion of said expandable conduit and a cooperating tab and shoulder portion associated with said pivotable members to limit expansion of said pivotable members.

45. The system of claim 31, wherein said first fastener further comprises a first housing defining a longitudinal axis and said first recess is defined in said first housing to receive said elongated member in an orientation substantially transverse to said longitudinal axis of said first housing.

5 46. The system of claim 45, wherein said first recess is defined by a pair of notches disposed between a pair of upright members in said first housing.

47. The system of claim 46, wherein an inner surface of said upright members defines a series of threads cooperative with a series of threads defined on said first clamping member.

10 48. The system of claim 31, the first fastener comprises a first screw portion for fixation to the first bone portion, a first housing movably mounted with respect to said first screw portion and defining said first recess for receiving said elongated member therein, and a first biasing member mounted in said first housing to apply a biasing force to drive a first spacer member into frictional engagement with  
15 said first screw member to restrict movement of said first housing with respect to said first screw portion.

49. The system of claim 48, wherein said first biasing member is selected such that said biasing force applied thereby to drive said first spacer member into frictional engagement with said first screw member is insufficient to resist application  
20 of a predetermined force applied by a user to move of said first housing with respect to said first screw member.

50. The system of claim 31, wherein said driver member is rotatable about said longitudinal axis to secure said first clamping member to said first fastener.

51. The system of claim 31, further comprising a pusher member  
25 configured to urge said elongated member in said first recess in said first fastener.

52. The system of claim 51, wherein the pusher member comprises a tubular member defining an internal lumen configured for coaxial positioning about said driver member.

53. The system of claim 51, wherein the pusher member comprises an  
30 internal lumen configured to guide said first clamping member to said first fastener.

54. The system of claim 31, further comprising an adjustment apparatus configured for insertion into said internal passage of said expandable conduit comprising a spacing member for applying a force to said second fastener to move said second bone portion with respect to said first bone portion.

55. The system of claim 54, wherein said adjustment apparatus further comprises a second driver member cooperative with said spacing member for securing said first clamping member with respect to said first fastener.

56. The system of claim 54, wherein the spacing member is pivotably  
5 mounted for movement between a first position adjacent said second driver member and a second position spaced apart from said second driver member.

57. The system of claim 31, further comprising an apparatus for supporting an endoscope comprising a base portion defining a bore in communication with said internal passage of said expandable conduit, and an endoscope mounting member  
10 movably mounted with respect to said base for supporting an endoscope within said internal passage of said expandable cannula.

58. The system of claim 57, wherein said base portion is rotatable about a longitudinal axis of said expandable conduit.

59. The system of claim 57, wherein said endoscope mounting member  
15 comprises a screw member positioned between said base and said endoscope mounting member to provide movement of said endoscope relative to said base in said longitudinal axis.

60. The system of claim 57, wherein said endoscope mounting member is movable with respect to said base in a direction substantially transverse to said  
20 longitudinal axis.

61. A method for performing surgical procedures on bone structures located beneath body tissue in a patient, comprising:

(a) percutaneously inserting an expandable conduit comprising a wall portion defining an internal passage therethrough into said body tissue with said  
25 wall portion in a first configuration having a first cross-sectional area at a distal portion thereof and moving said wall portion to said second configuration having an enlarged cross-sectional area at said distal portion thereof;

(b) providing a first fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a first bone portion, the  
30 first fastener defining a first recess for receiving a portion of said elongated member therein, said first fastener comprising a first clamping member attachable to said first fastener to clamp said elongated member and first fastener into fixed engagement;

(c) providing a second fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a second bone portion,



the second fastener defining a second recess for receiving a portion of said elongated member therein, said second fastener comprising a second clamping member attachable to said second fastener to clamp said elongated member and second fastener into fixed engagement;

5 (d) attaching said first and said second fastener into said first and second respective bone portions;

(e) inserting an elongated member in said internal passage of said expandable conduit and moving said elongated member into said first and second recesses in said first and second respective fasteners; and

10 (f) securing said first and second clamping member to said first and second respective fasteners to fixedly secure said elongated member to said first and second fasteners.

62. The method of claim 61, wherein the step of attaching said first and said second fasteners into said first and second respective bone portions comprises  
15 attaching said first and said second fasteners into a first and second vertebra.

63. The method of claim 61, wherein said step of moving said wall portion to said second enlarged cross-sectional area comprises resiliently expanding said wall portion from said first configuration to said second configuration.

64. The method of claim 61, further comprising:  
20 providing an expansion instrument having a remotely actuatable distal portion movable between an approximated configuration and a spaced apart configuration, and

expanding said expansion instrument while positioned in said internal passage of said expandable conduit to said spaced apart configuration to expand said  
25 cross-sectional area defined by said wall portion thereof.

65. The method of claim 64, wherein said wall portion comprises a proximal wall portion and a distal wall portion movable relative to said proximal wall portion, and wherein said step of expanding said expansion instrument while positioned in said internal passage of said expandable conduit comprises moving said  
30 distal wall portion relative to said proximal wall portion.

66. The method of claim 64, wherein said expansion instrument comprises a stop configured to engage a proximal portion of said expandable conduit to limit insertion of said expansion instrument into said internal passage of said expandable conduit, and wherein the method further comprises inserting said expansion

instrument into said internal passage until said stop engages said proximal portion of said expandable conduit.

67. The method of claim 64, wherein said expansion instrument comprises a pair of pivotable members for engaging an interior portion of said wall portion and a cooperating tab and shoulder portion associated with said pivotable members to limit expansion of said pivotable members, and wherein said step of expanding said expansion instrument while positioned in said internal passage of said expandable conduit comprises expanding said pivotable members until said cooperating tab and shoulder portions are in engagement with respect to one another.

68. The method of claim 61, wherein said wall portion of said expandable conduit defines a notch portion at a distal portion thereof configured to allow said elongated member to pass therethrough, and wherein said step of inserting said elongated member in said internal passage of said expandable conduit comprises passing an end portion of said elongated member through said notch portion.

69. The method of claim, 61 further comprising providing a driver member configured for insertion into said internal passage of said expandable conduit to secure said first clamping member to said first fastener.

70. The method of claim 69 further comprising providing a pusher member configured to urge said elongated member in said first recess in said first fastener.

71. The method of claim 70, wherein said pusher member is coaxially disposed about said driver member, and wherein said step of applying a longitudinal force to said elongated member comprises applying a longitudinal force distributed about said driver member.

72. The method of claim 70, wherein said pusher member comprises an internal lumen sized to receive at least one of said first and second clamping members slidably therethrough and wherein said step securing said first and second clamping member to said first and second respective fasteners comprises sliding at least one of said first and second clamping members within said internal lumen to said respective first and second fastener.

73. The method of claim 69, wherein said driver member is rotatable about said longitudinal axis to secure said first clamping member to said first fastener, and said step of securing said clamping member comprises rotating said first clamping member with respect said first fastener.

74. The method of claim 61, further comprising:  
providing an adjustment apparatus comprising a spacing member for  
applying a force to one of said first and second fasteners to move one of said first and  
second bone portions attached thereto relative to an adjacent one of said first and  
5 second bone portions; and

applying said force with said spacing member to said one of said first  
and second fasteners to move said one of said first and second bone portions attached  
to relative to said adjacent one of said first and second bone portions.

75. The method of claim 74, wherein said adjustment apparatus further  
10 comprises a second driver member cooperative with said spacing member for  
securing said first clamping member with respect to said first fastener, wherein said  
method further comprises cooperatively securing said first clamping member to said  
first fastener while said spacing member applies said force to said second fastener.

76. The method of claim 61, further comprising  
15 providing an apparatus for supporting an endoscope comprising a base  
portion defining a bore in communication with said internal passage of said  
expandable conduit, and an endoscope mounting member movably mounted with  
respect to said base for supporting an endoscope within said internal passage of said  
expandable cannula.

20 77. The method of claim 76, further comprising, after said step of  
percutaneously inserting said expandable conduit in said body tissue, mounting said  
apparatus for supporting said endoscope on said proximal portion of said expandable  
conduit such that said bore is in communication with said internal passage of said  
expandable conduit.

25 78. The method of claim 77, further comprising, after said step of  
mounting said apparatus for supporting said endoscope, rotating said apparatus for  
supporting said endoscope about a longitudinal axis of said internal passage of said  
expandable conduit.

30 79. The method of claim 77, further comprising, after said step of  
mounting said apparatus for supporting said endoscope, moving said endoscope  
mounting member relative to said base along said longitudinal axis of said internal  
passage of said expandable conduit.

80. The method of claim 77, further comprising, after said step of  
mounting said apparatus for supporting said endoscope, moving said endoscope

mounting member relative to said base in a direction substantially transverse to said longitudinal axis of said internal passage of said expandable conduit.

81. A method for performing surgical procedures on bone structures located beneath body tissue in a patient, comprising:

- 5 (a) percutaneously inserting an expandable conduit comprising a wall portion defining an internal passage therethrough into said body tissue with said wall portion in a first configuration having a first cross-sectional area at a distal portion thereof and moving said wall portion to said second configuration having an enlarged cross-sectional area at said distal portion thereof ;
- 10 (b) providing a first fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a first bone portion, the first fastener defining a first recess for receiving a portion of said elongated member therein, said first fastener comprising a first clamping member attachable to said first fastener to clamp said elongated member and first fastener into fixed engagement;
- 15 (c) providing a second fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a second bone portion, the second fastener defining a second recess for receiving a portion of said elongated member therein, said second fastener comprising a second clamping member attachable to said second fastener to clamp said elongated member and second  
20 fastener into fixed engagement;
- (d) providing a third fastener configured for insertion into said internal passage of said expandable conduit and for fixation to a second bone portion, the third fastener defining a third recess for receiving a portion of said elongated member therein, said third fastener comprising a third clamping member attachable to  
25 said third fastener to clamp said elongated member and third fastener into fixed engagement;
- (e) attaching said first, second, and third fastener into said first, second, and third respective bone portions;
- (f) inserting an elongated member in said internal passage of said  
30 expandable conduit and moving said elongated member into said first, second, and third recesses in said first and second respective fasteners; and
- (g) securing said first, second, and third clamping member to said first, second, and third respective fasteners to fixedly secure said elongated member to said first, second, and third fasteners.

82. The method of claim 81, wherein the step of attaching said first, second, and third fasteners into said first, second, and third respective bone portions comprises attaching said first, second, and third fasteners into a first, second, and third vertebra.

5 83. The method of claim 81, wherein said step of moving said wall portion to said second enlarged cross-sectional area comprises resiliently expanding said wall portion from said first configuration to said second configuration.

84. The method of claim 81, further comprising:  
providing an expansion instrument having a remotely actuatable distal  
10 portion movable between an approximated configuration and a spaced apart configuration, and

expanding said expansion instrument while positioned in said internal passage of said expandable conduit to said spaced apart configuration to expand said cross-sectional area defined by said wall portion thereof.

15 85. The method of claim 84, wherein said wall portion comprises a proximal wall portion and a distal wall portion movable relative to said proximal wall portion, and wherein said step of expanding said expansion instrument while positioned in said internal passage of said expandable conduit comprises moving said distal wall portion relative to said proximal wall portion.

20 86. The method of claim 84, wherein said expansion instrument comprises a stop configured to engage a proximal portion of said expandable conduit to limit insertion of said expansion instrument into said internal passage of said expandable conduit, and wherein the method further comprises inserting said expansion instrument into said internal passage until said stop engages said proximal portion of  
25 said expandable conduit.

87. The method of claim 84, wherein said expansion instrument comprises a pair of pivotable members for engaging an interior portion of said wall portion and a cooperating tab and shoulder portion associated with said pivotable members to limit expansion of said pivotable members, and wherein said step of expanding said  
30 expansion instrument while positioned in said internal passage of said expandable conduit comprises expanding said pivotable members until said cooperating tab and shoulder portions are in engagement with respect to one another.

88. The method of claim 81, wherein said wall portion of said expandable conduit defines a notch portion at a distal portion thereof configured to allow said

elongated member to pass therethrough, and wherein said step of inserting said elongated member in said internal passage of said expandable conduit comprises passing an end portion of said elongated member through said notch portion.

89. The method of claim, 81 further comprising providing a driver member  
5 configured for insertion into said internal passage of said expandable conduit to secure said first clamping member to said first fastener.

90. The method of claim 89 further comprising providing a pusher member configured to urge said elongated member in said first recess in said first fastener.

91. The method of claim 90, wherein said pusher member is coaxially  
10 disposed about said driver member, and wherein said step of applying a longitudinal force to said elongated member comprises applying a longitudinal force distributed about said driver member.

92. The method of claim 90, wherein said pusher member comprises an internal lumen sized to receive at least one of said first and second clamping members  
15 slidably therethrough and wherein said step securing said first and second clamping member to said first and second respective fasteners comprises sliding at least one of said first and second clamping members within said internal lumen to said respective first and second fastener.

93. The method of claim 89, wherein said driver member is rotatable about  
20 said longitudinal axis to secure said first clamping member to said first fastener, and said step of securing said clamping member comprises rotating said first clamping member with respect said first fastener.

94. The method of claim 81, further comprising:  
providing an adjustment apparatus comprising a spacing member for  
25 applying a force to one of said first, second, and third fasteners to move one of said first, second, and third bone portions attached thereto relative to an adjacent one of said first, second, and third bone portions; and

applying said force with said spacing member to said one of said first, second, and third fasteners to move said one of said first, second, and third bone  
30 portions attached thereto relative to said adjacent one of said first, second, and third bone portions.

95. The method of claim 94, wherein said adjustment apparatus further comprises a second driver member cooperative with said spacing member for securing said first clamping member with respect to said first fastener, wherein said

method further comprises cooperatively securing said first clamping member to said first fastener while said spacing member applies said force to said second fastener.

96. The method of claim 81, further comprising  
providing an apparatus for supporting an endoscope comprising a base  
5 portion defining a bore in communication with said internal passage of said  
expandable conduit, and an endoscope mounting member movably mounted with  
respect to said base for supporting an endoscope within said internal passage of said  
expandable cannula.

97. The method of claim 96, further comprising, after said step of  
10 percutaneously inserting said expandable conduit in said body tissue, mounting said  
apparatus for supporting said endoscope on said proximal portion of said expandable  
conduit such that said bore is in communication with said internal passage of said  
expandable conduit.

98. The method of claim 97, further comprising, after said step of  
15 mounting said apparatus for supporting said endoscope, rotating said apparatus for  
supporting said endoscope about a longitudinal axis of said internal passage of said  
expandable conduit.

99. The method of claim 97, further comprising, after said step of  
mounting said apparatus for supporting said endoscope, moving said endoscope  
20 mounting member relative to said base along said longitudinal axis of said internal  
passage of said expandable conduit.

100. The method of claim 97, further comprising, after said step of  
mounting said apparatus for supporting said endoscope, moving said endoscope  
mounting member relative to said base in a direction substantially transverse to said  
25 longitudinal axis of said internal passage of said expandable conduit.

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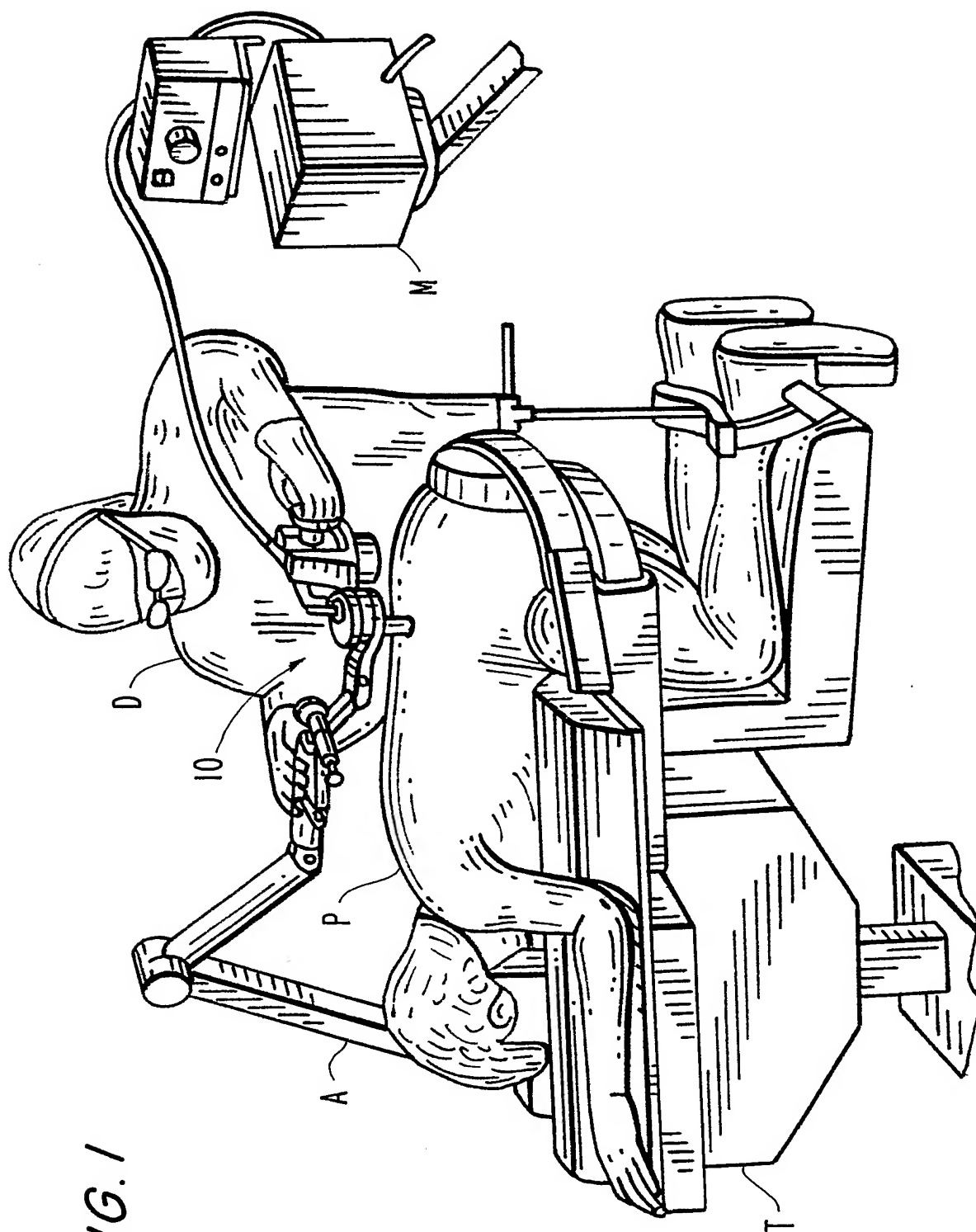
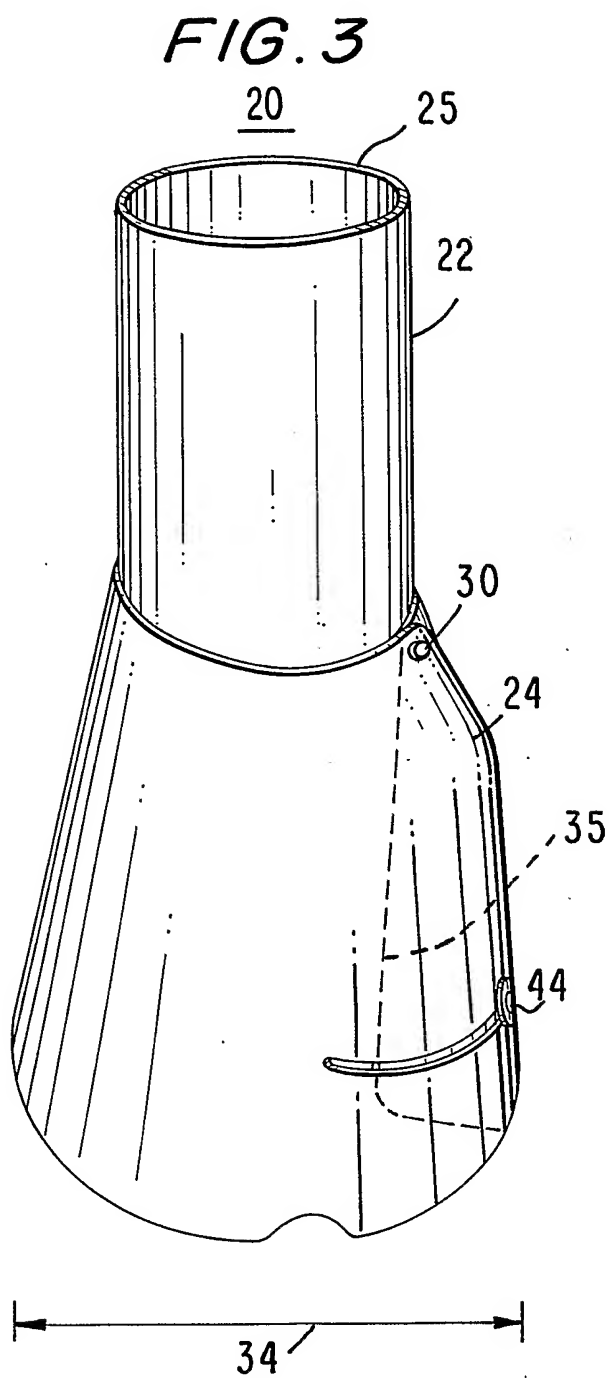
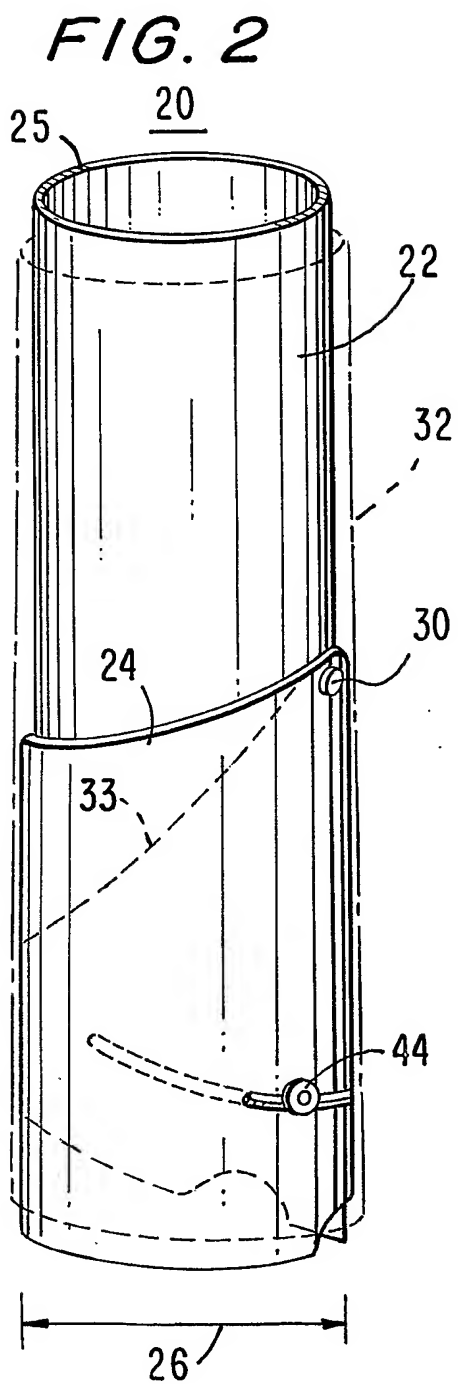


FIG. 1

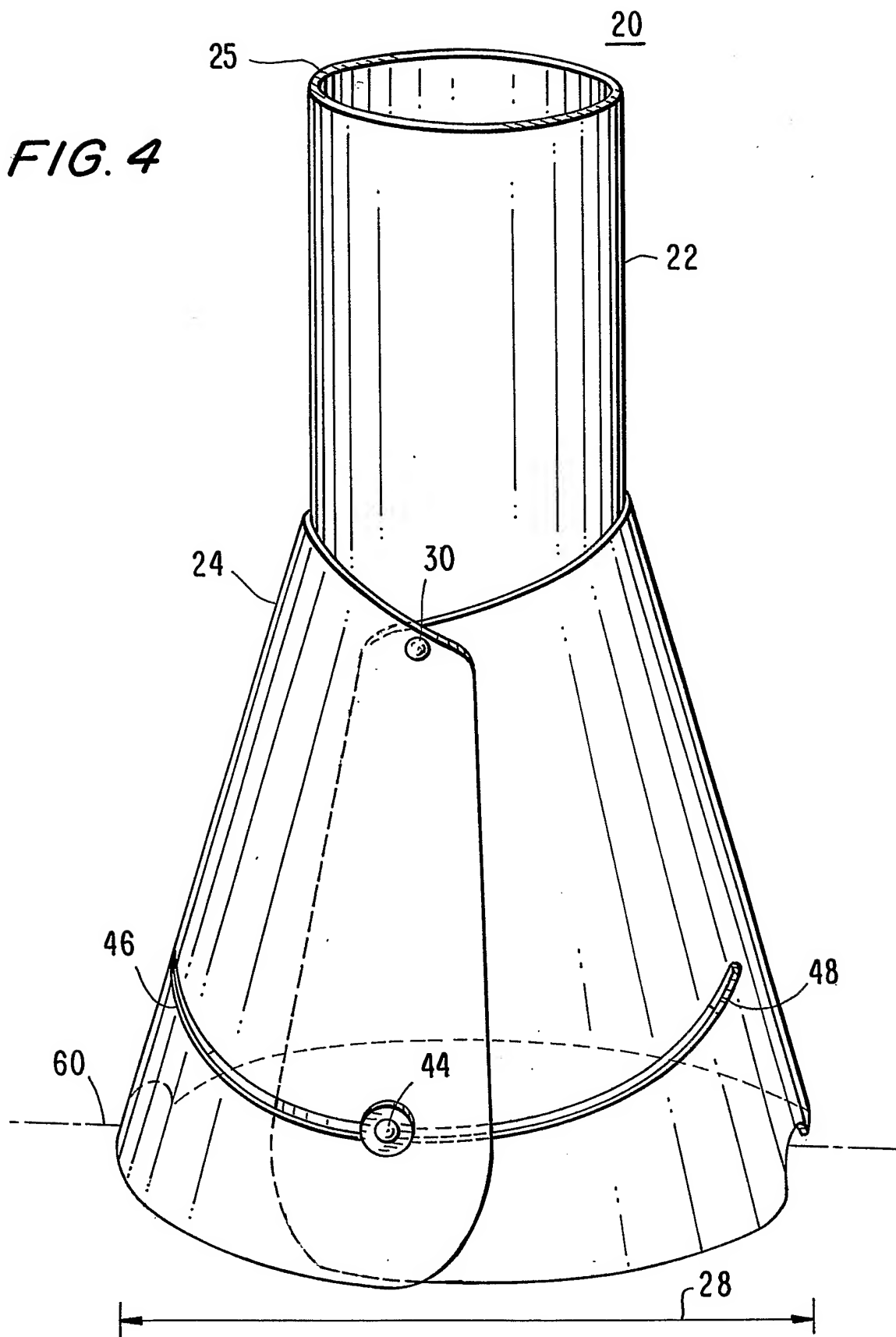


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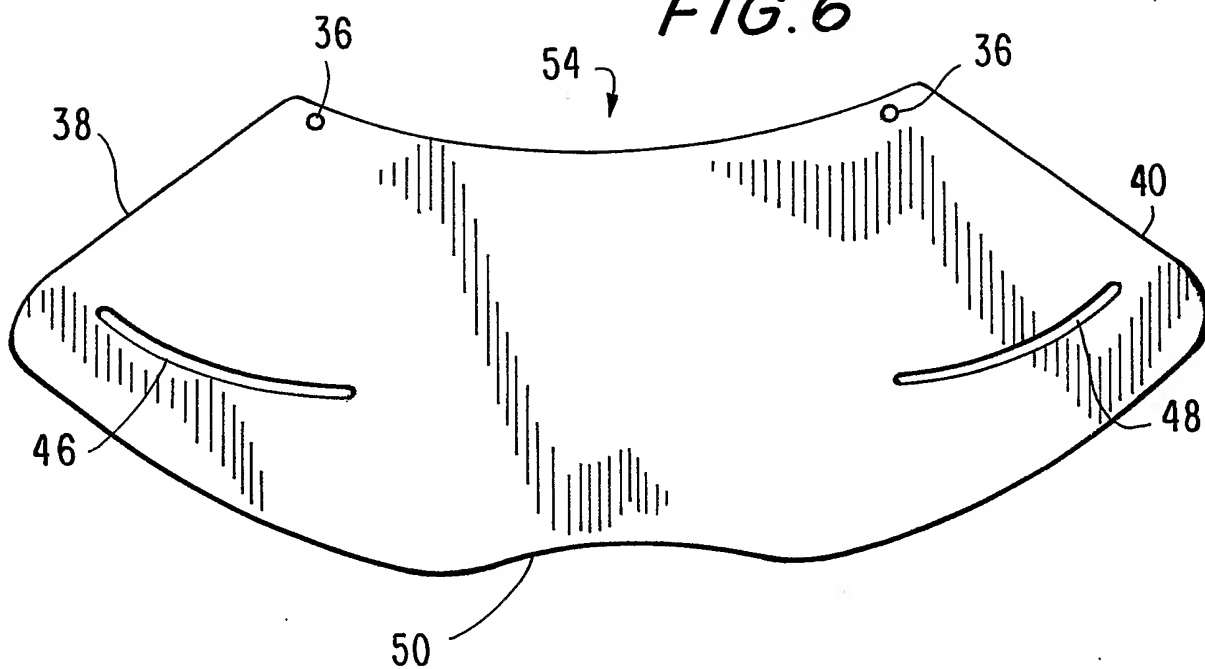
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**FIG. 4**

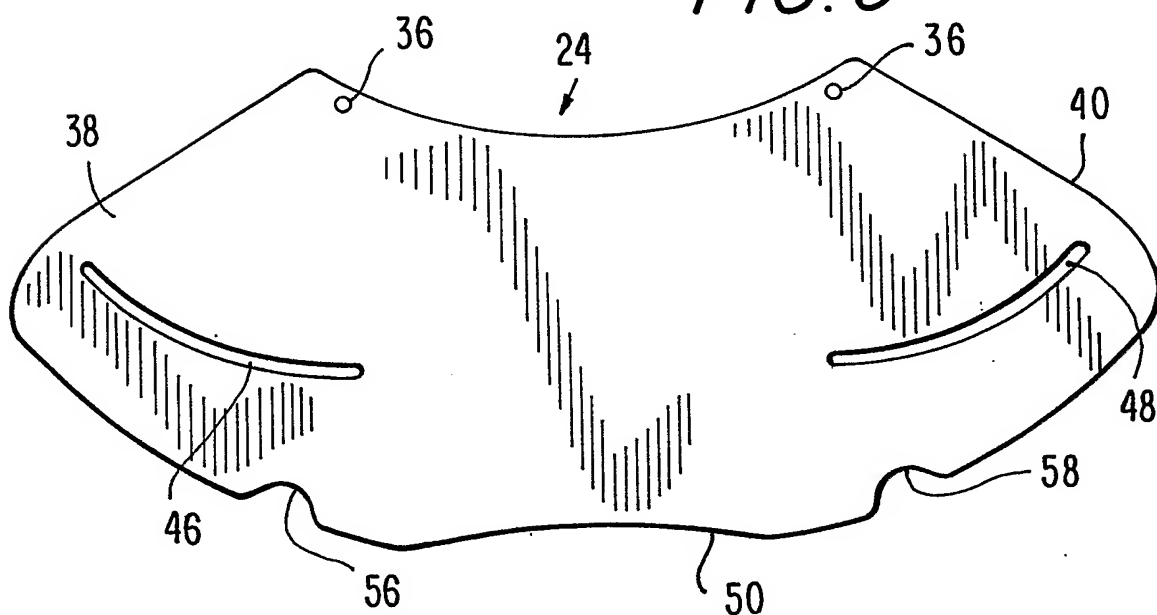


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**FIG. 6**

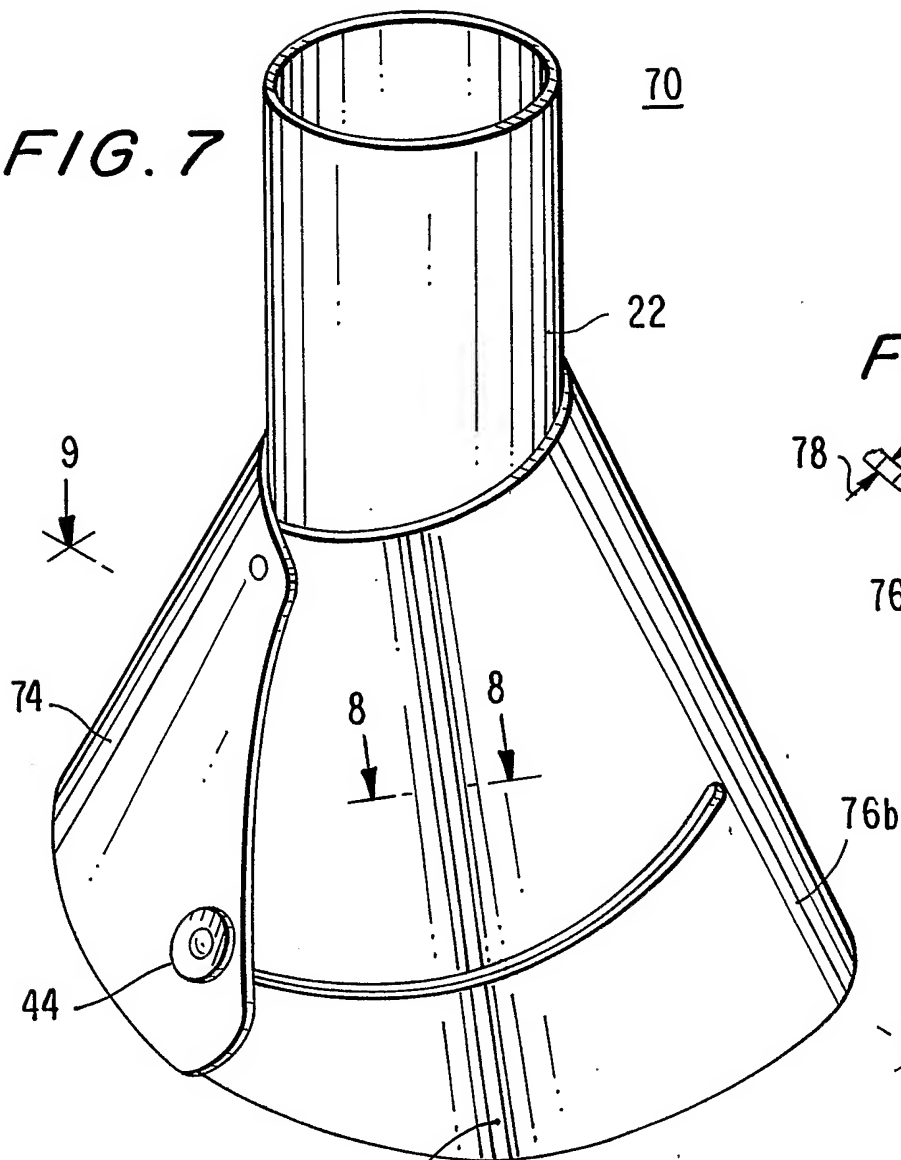


**FIG. 5**

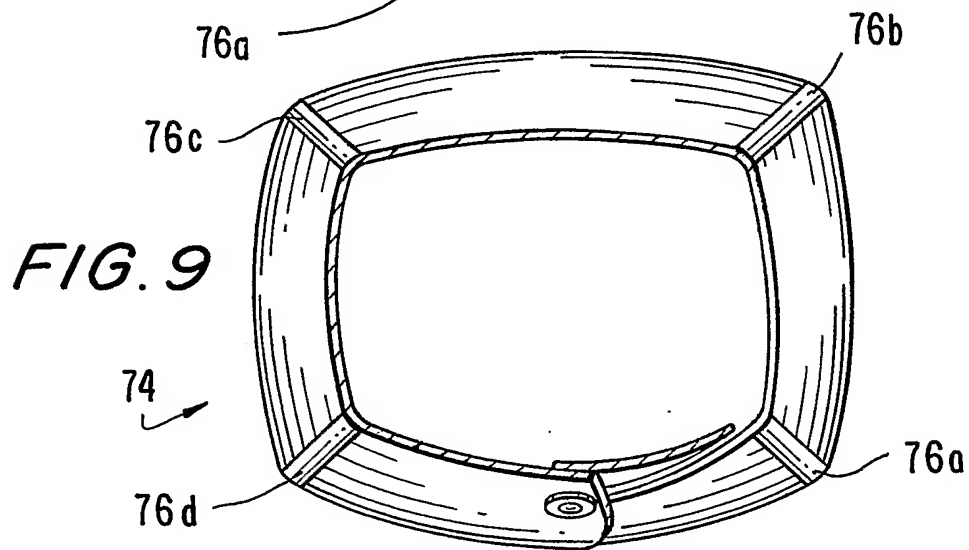
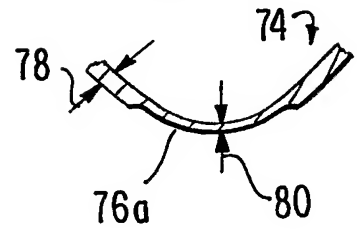


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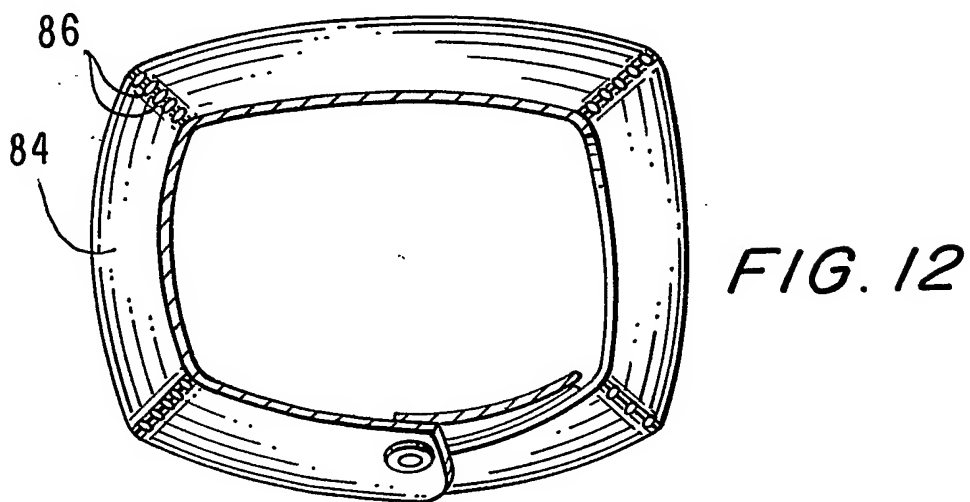
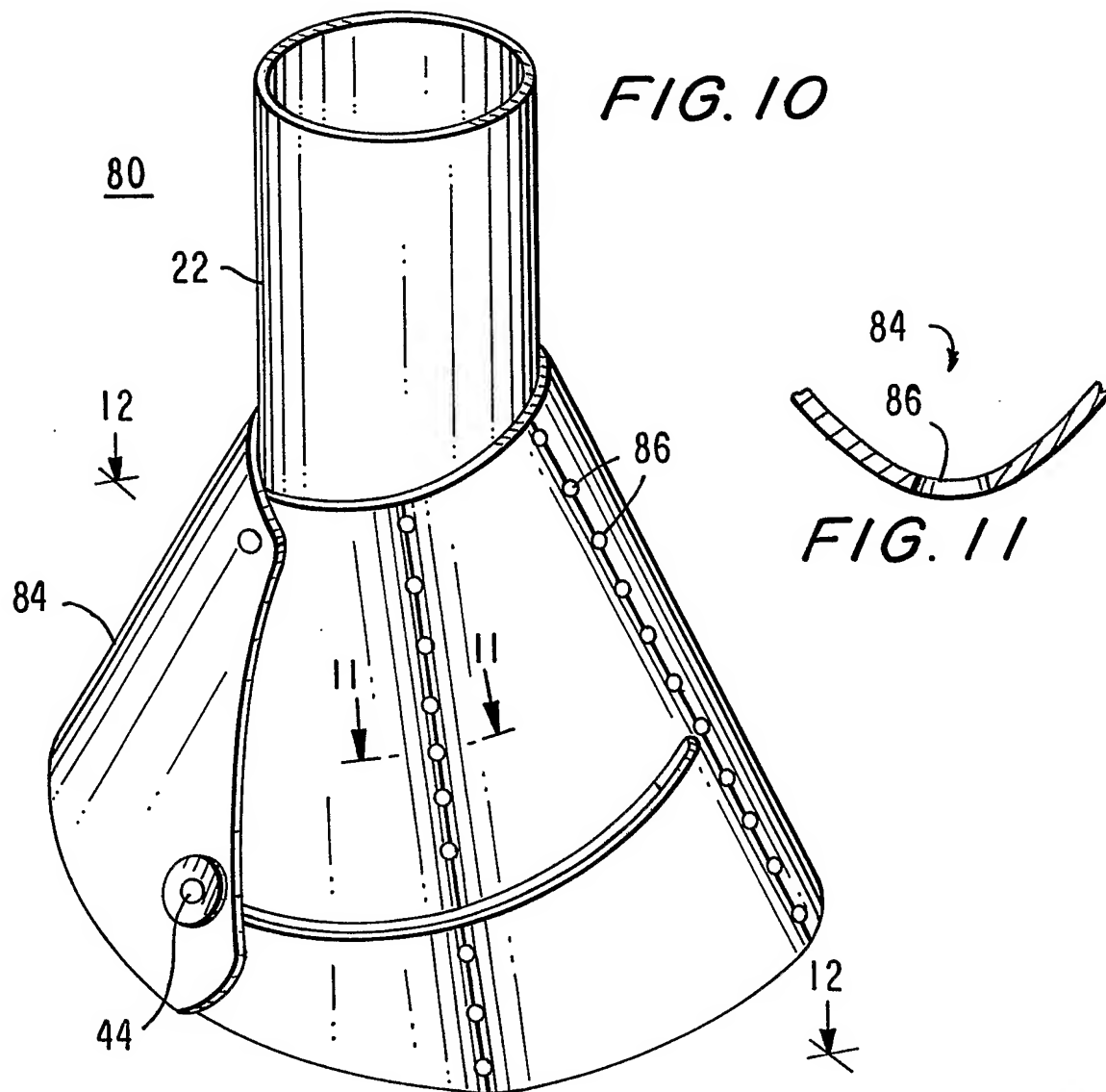
**FIG. 7**



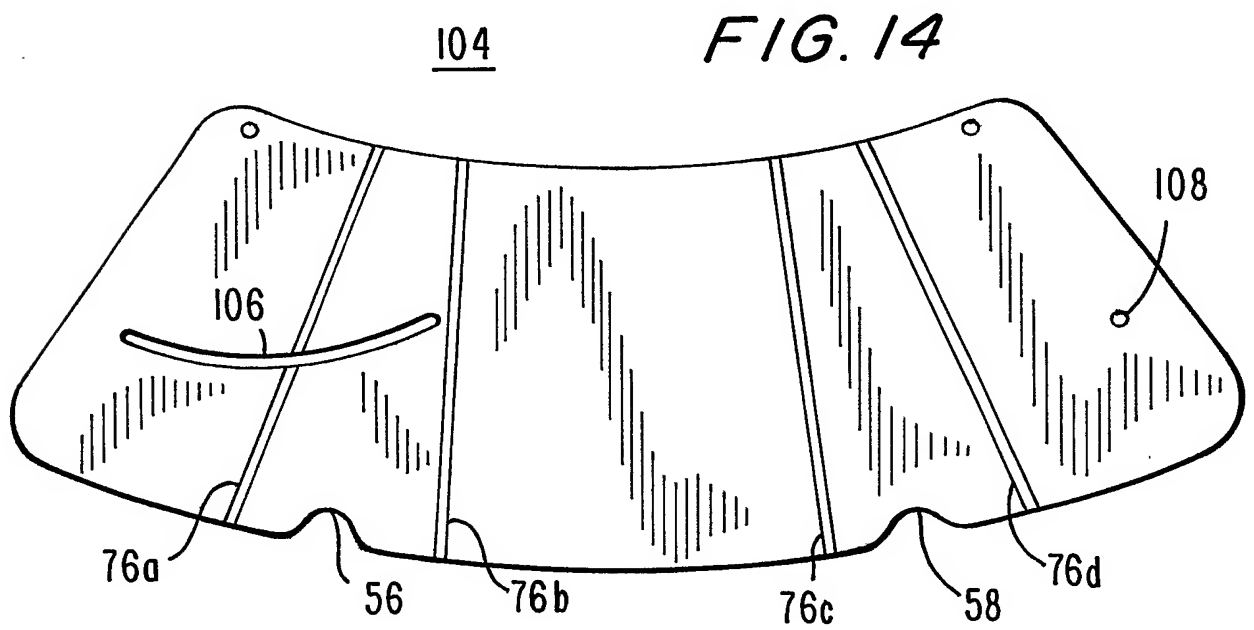
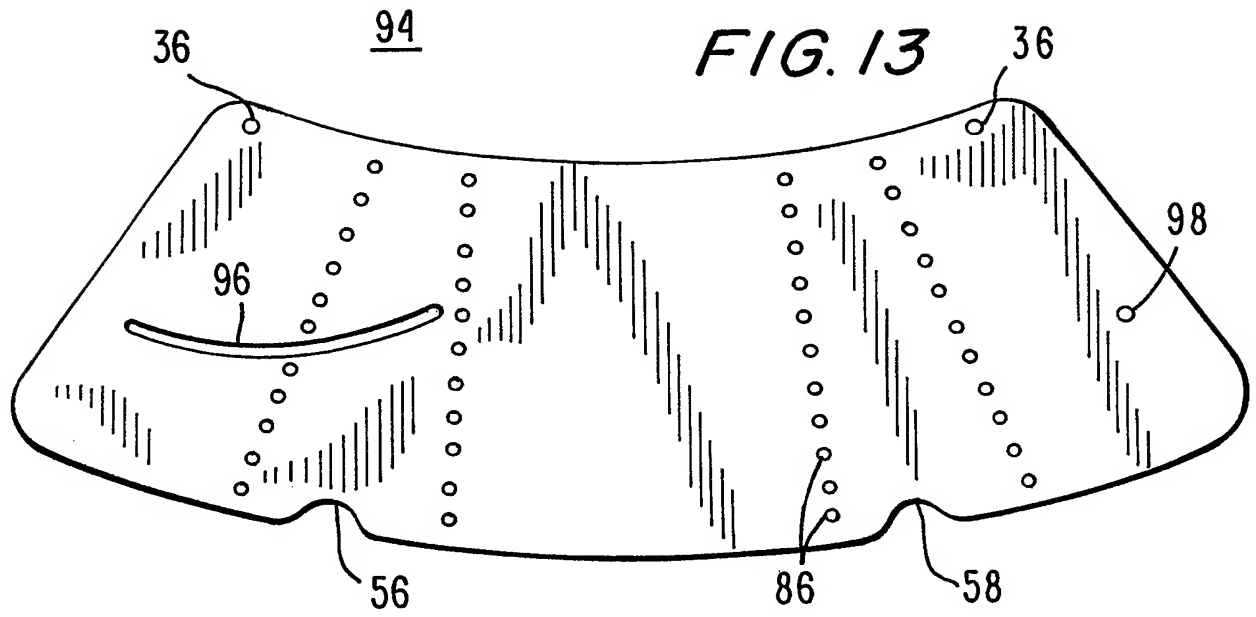
**FIG. 8**

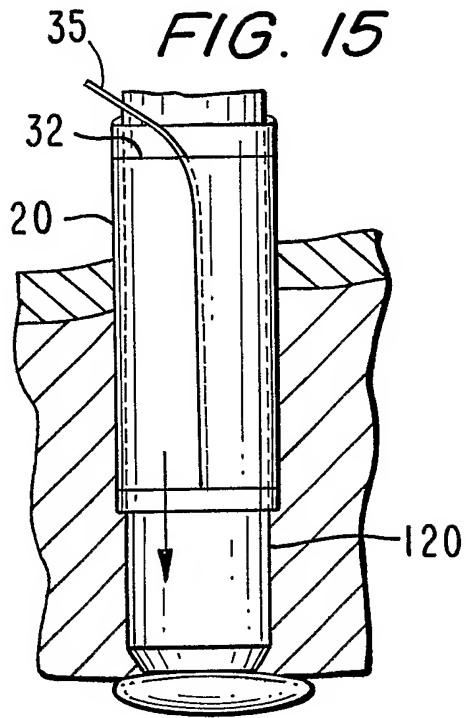


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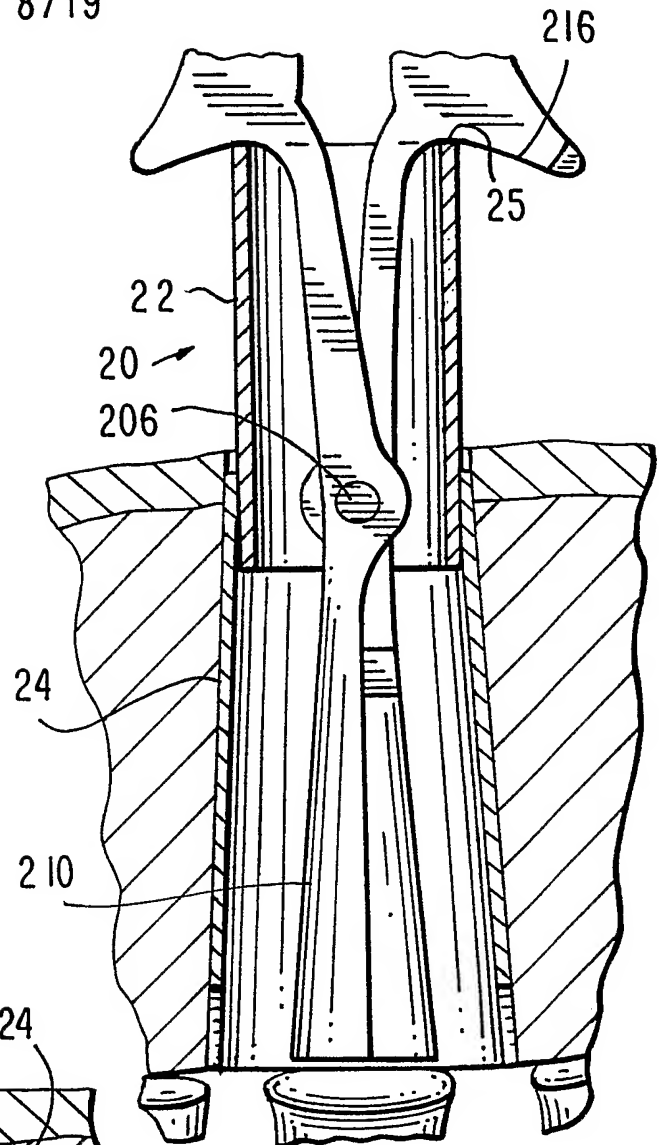


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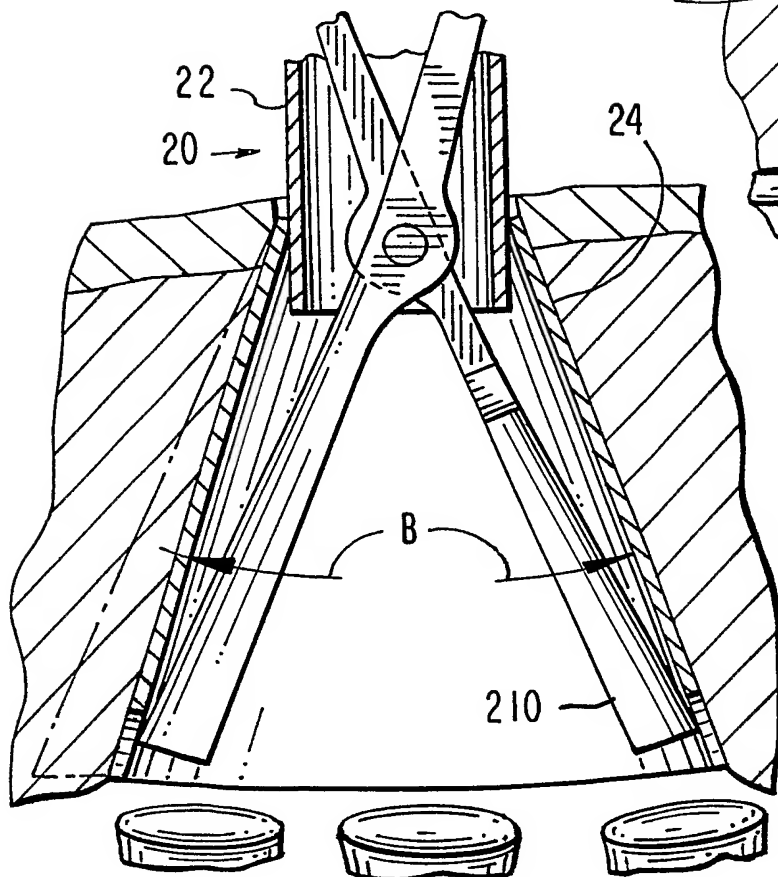




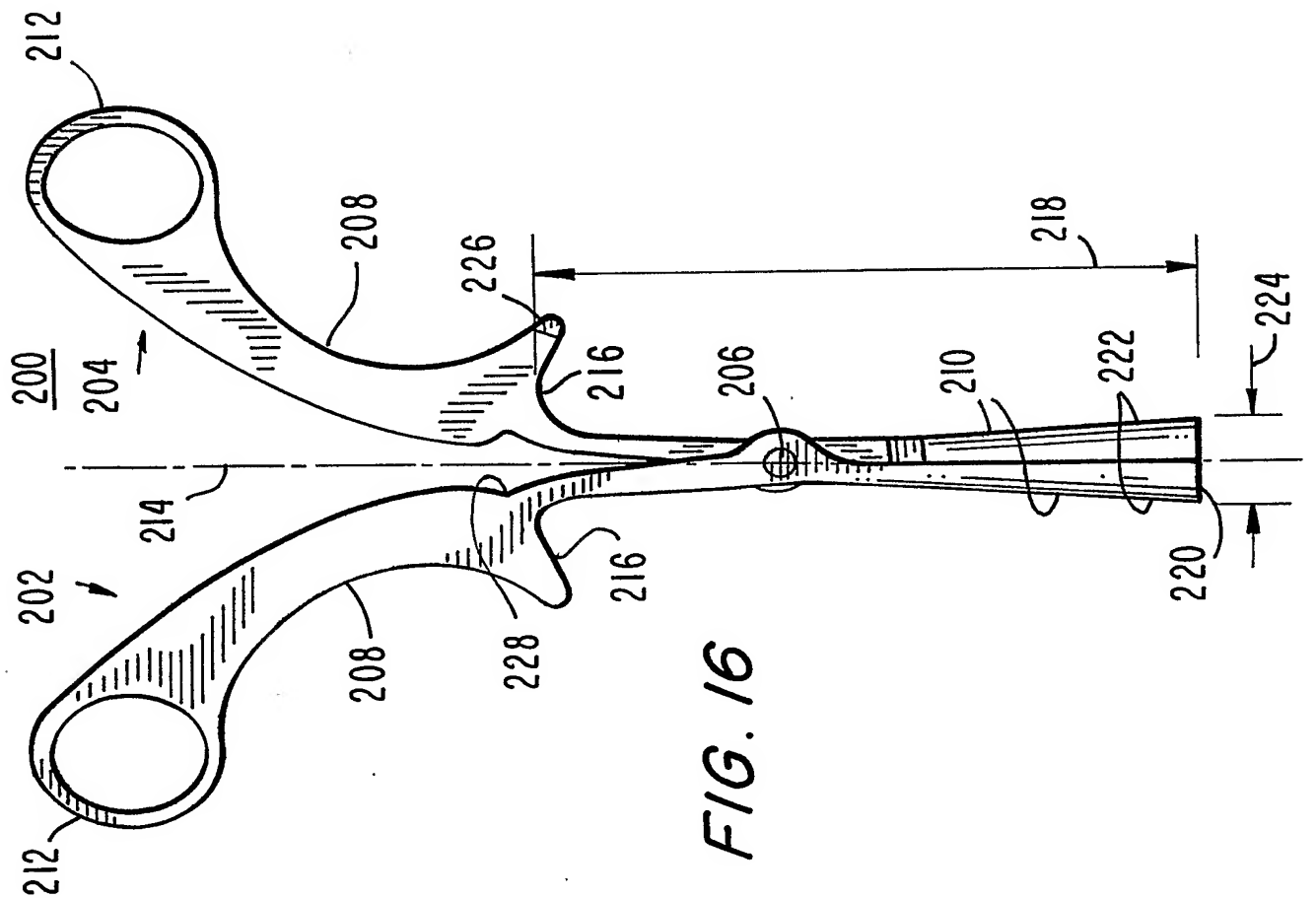
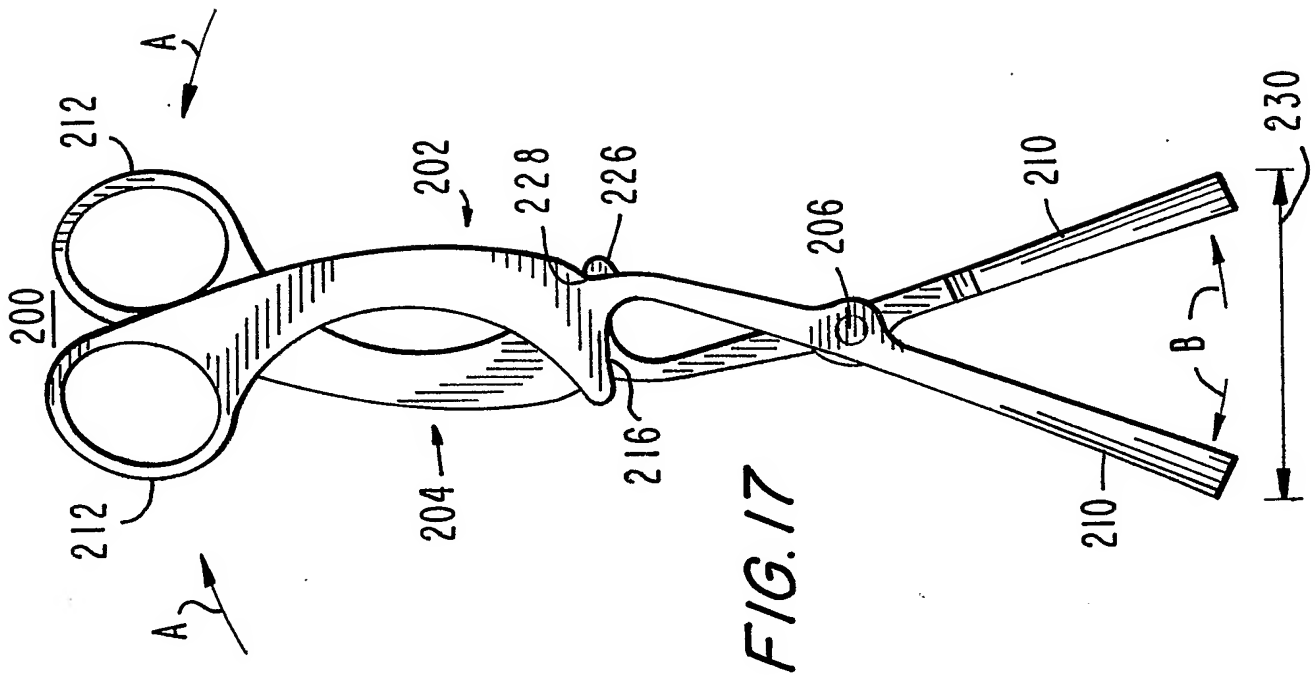
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**FIG. 18**

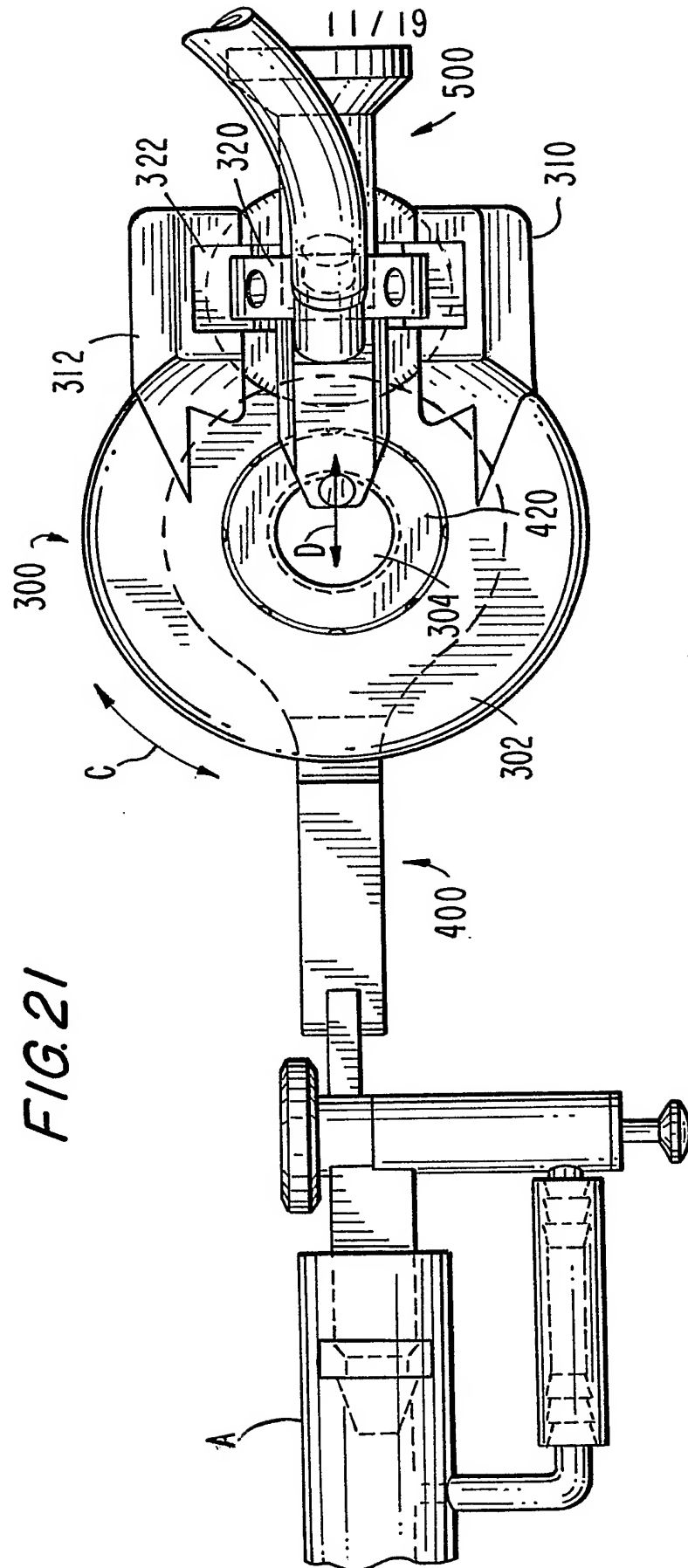


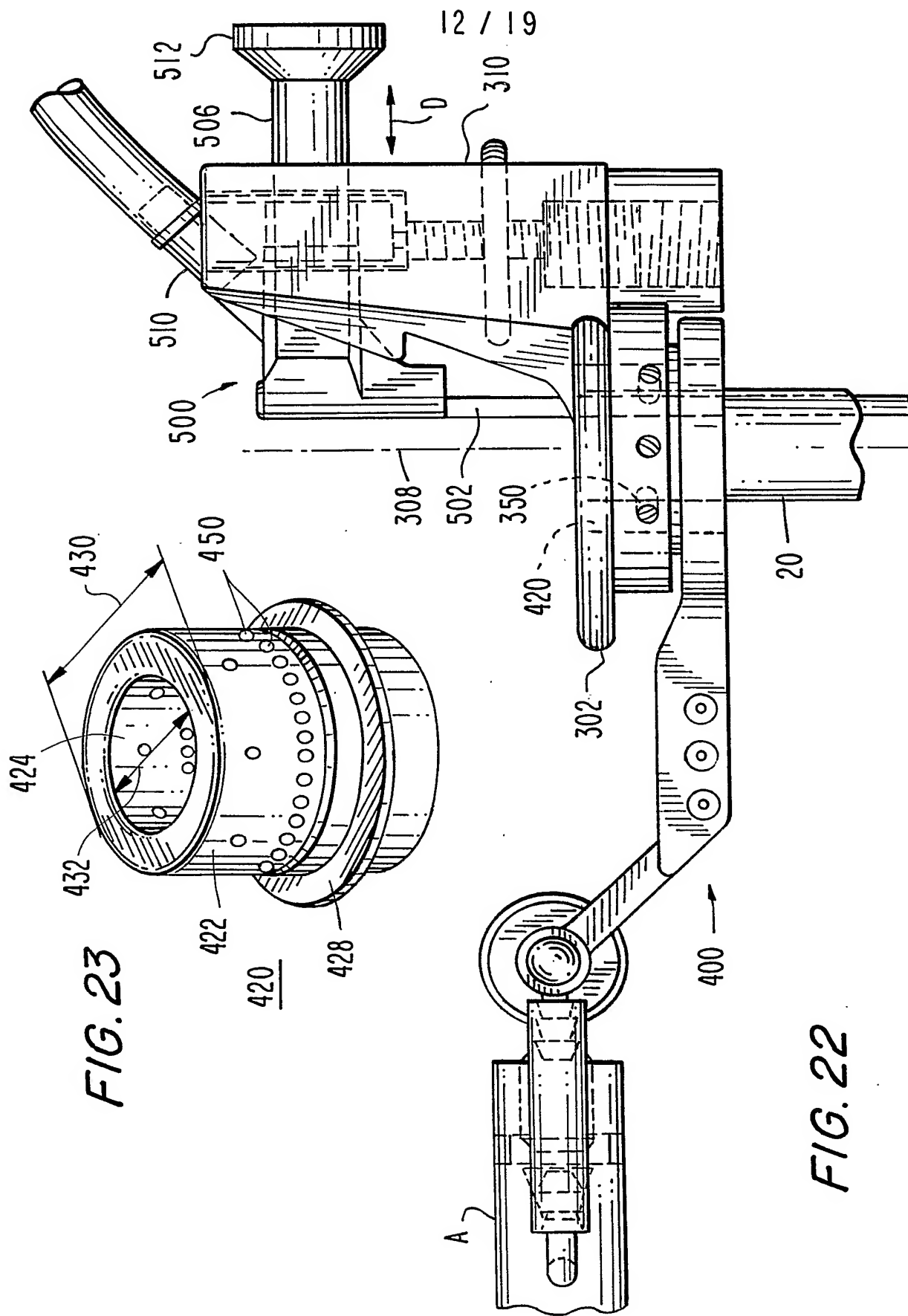
**FIG. 19**



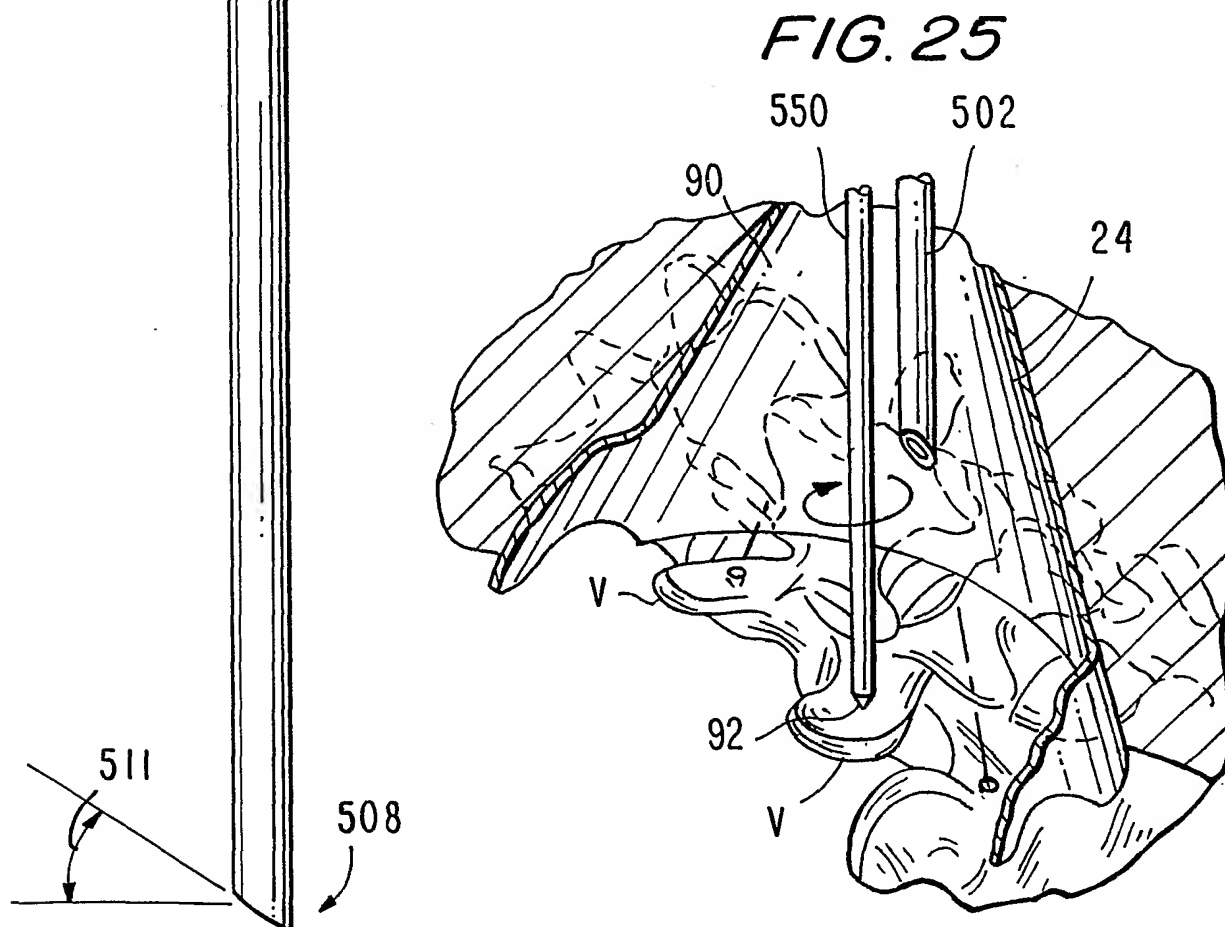
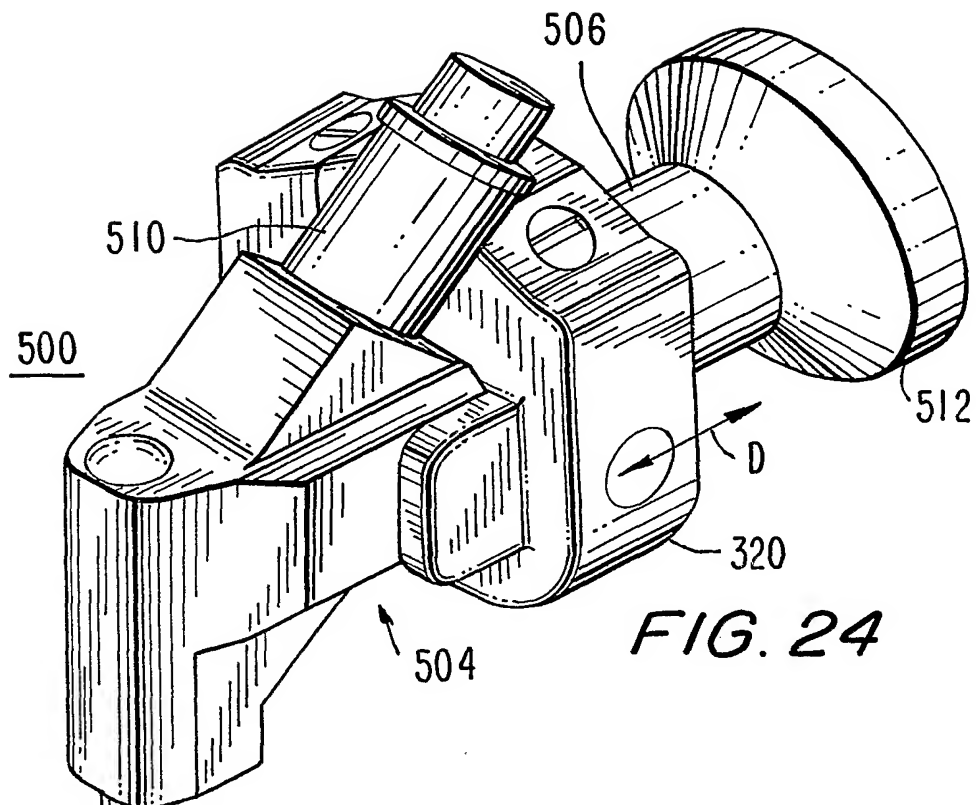


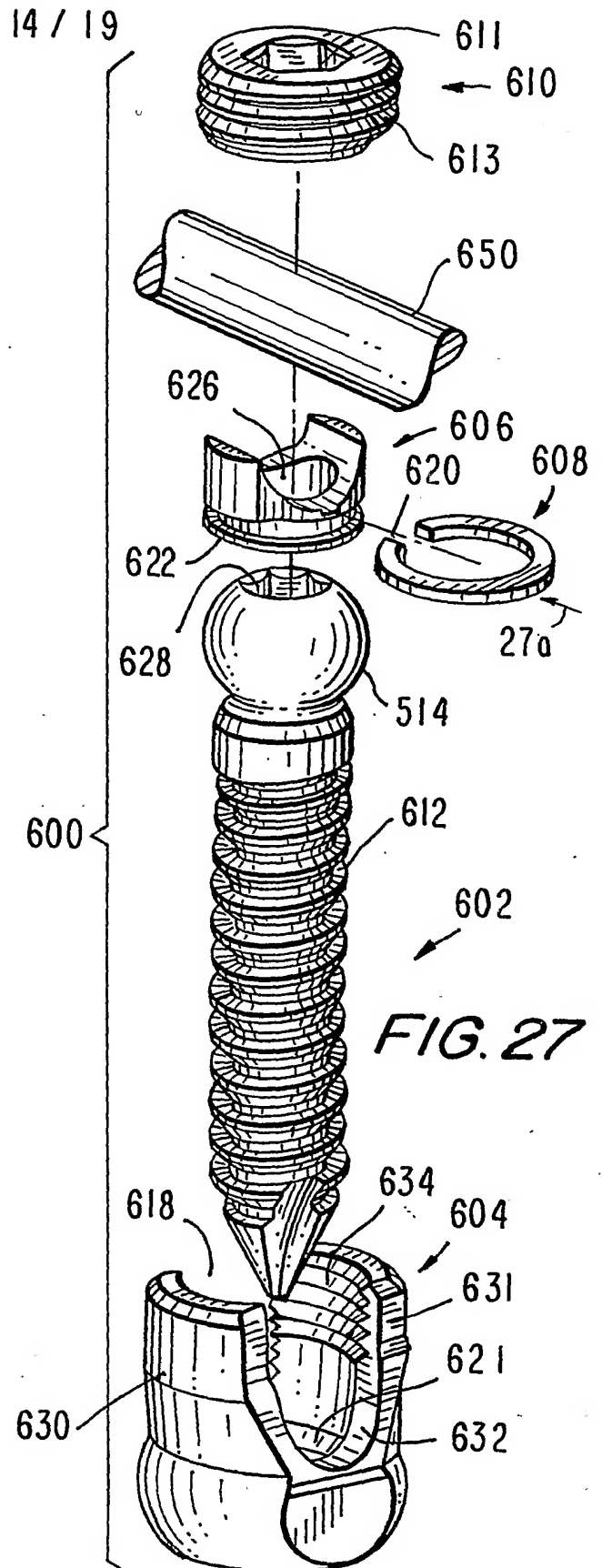
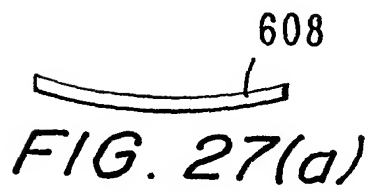
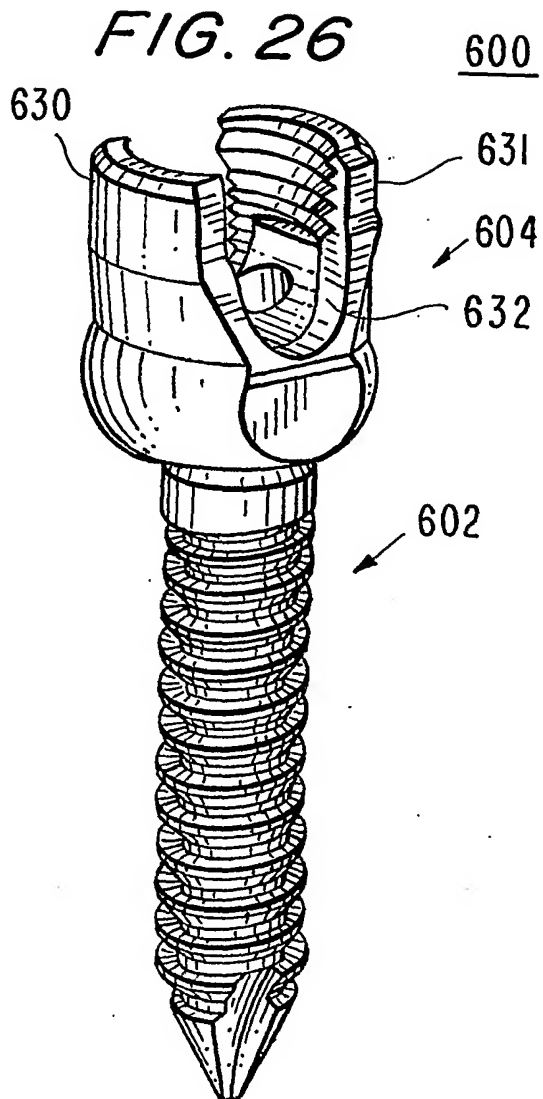






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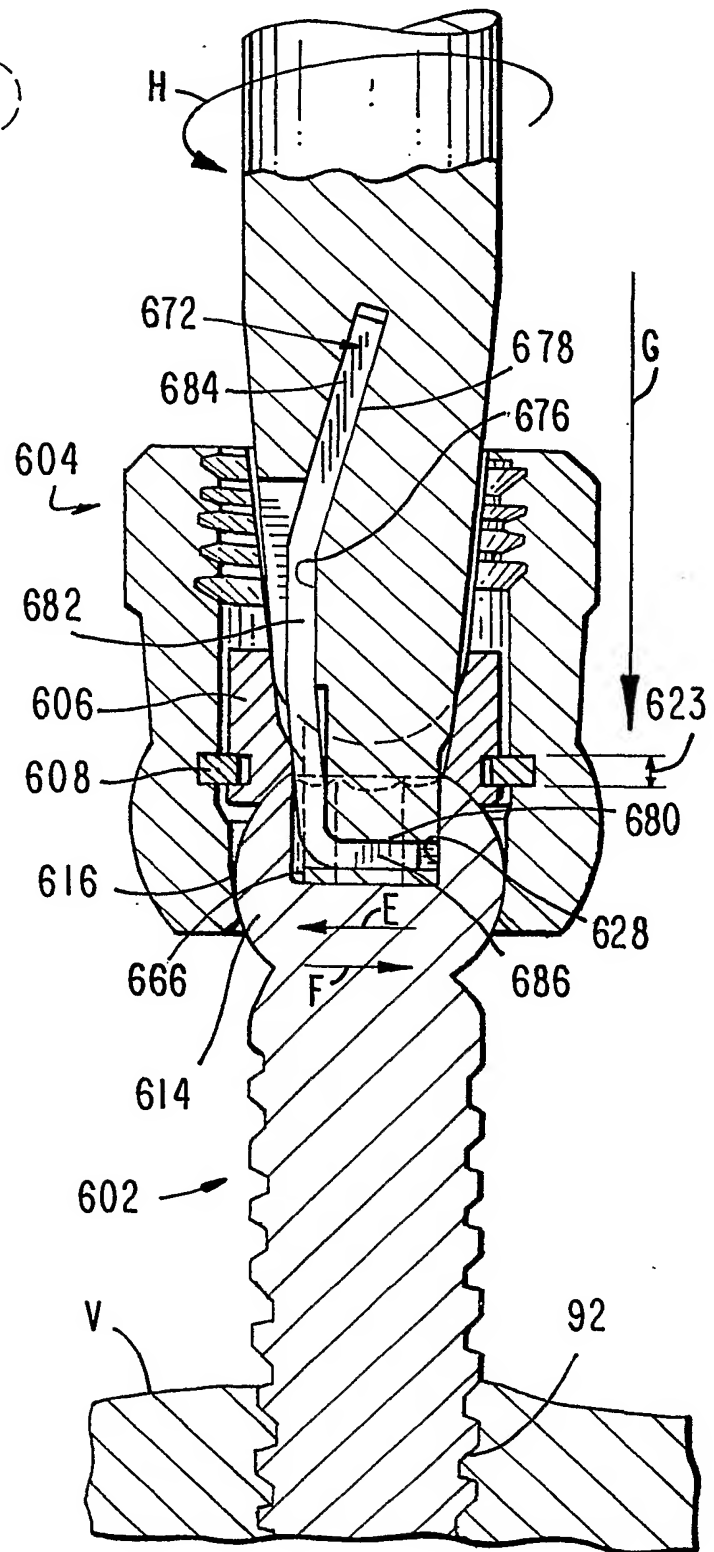
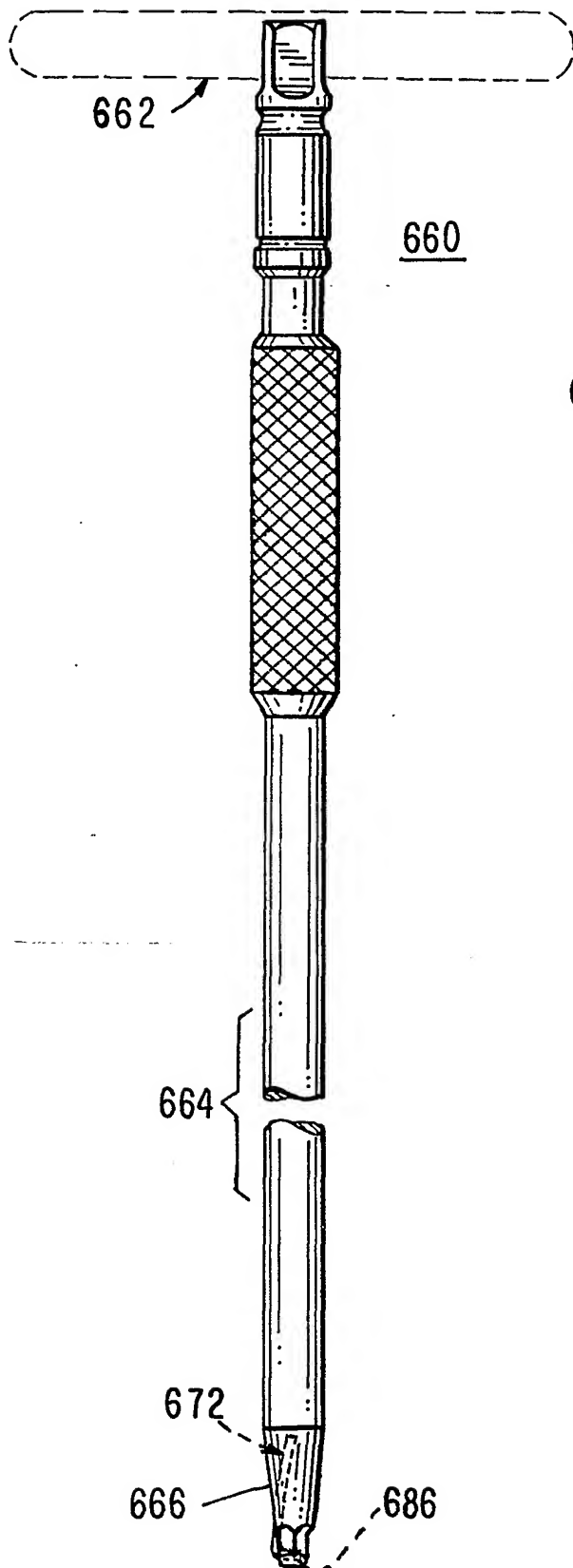




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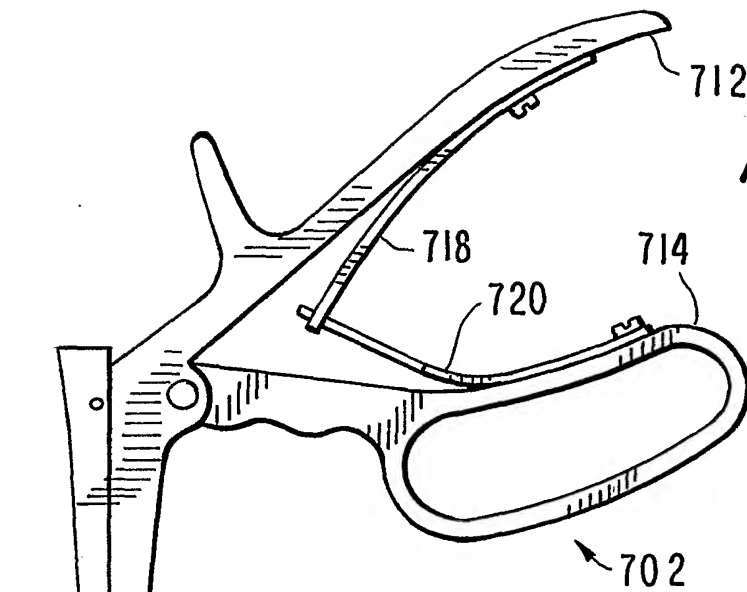
FIG. 28

FIG. 29



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**FIG. 30**



**FIG. 31**

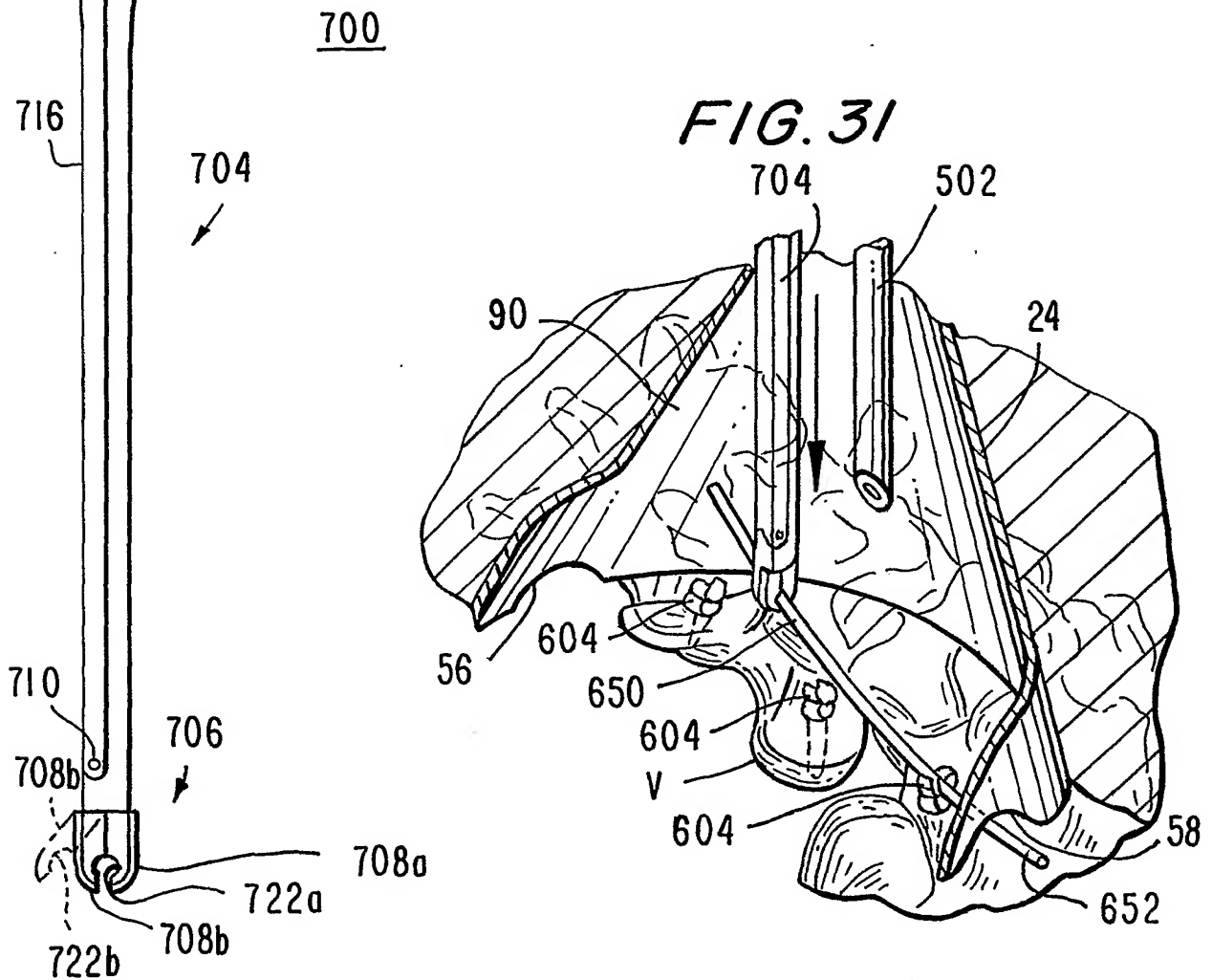


FIG. 32

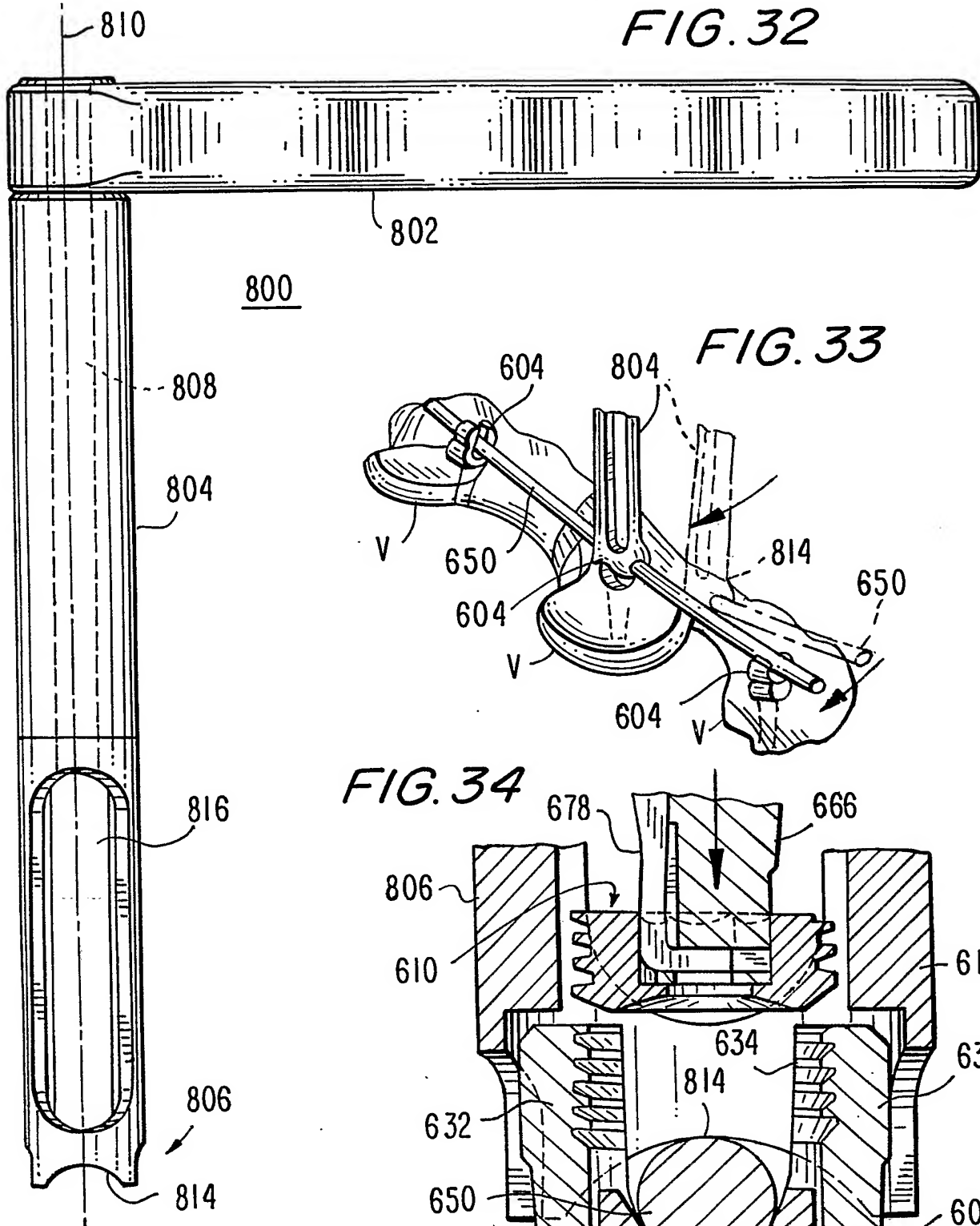


FIG. 33

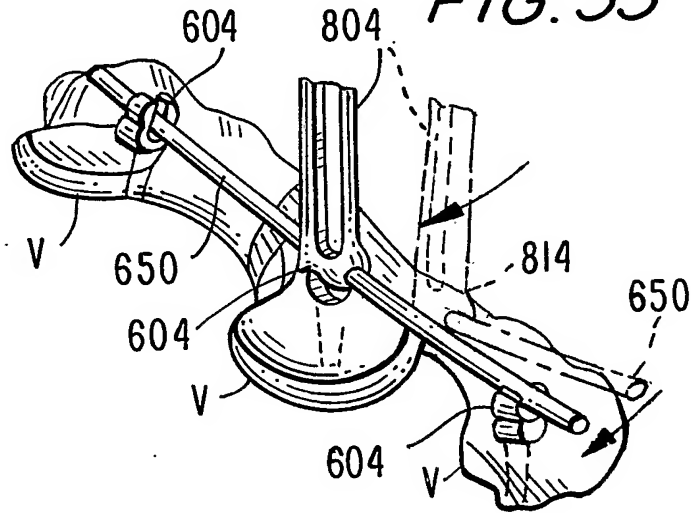
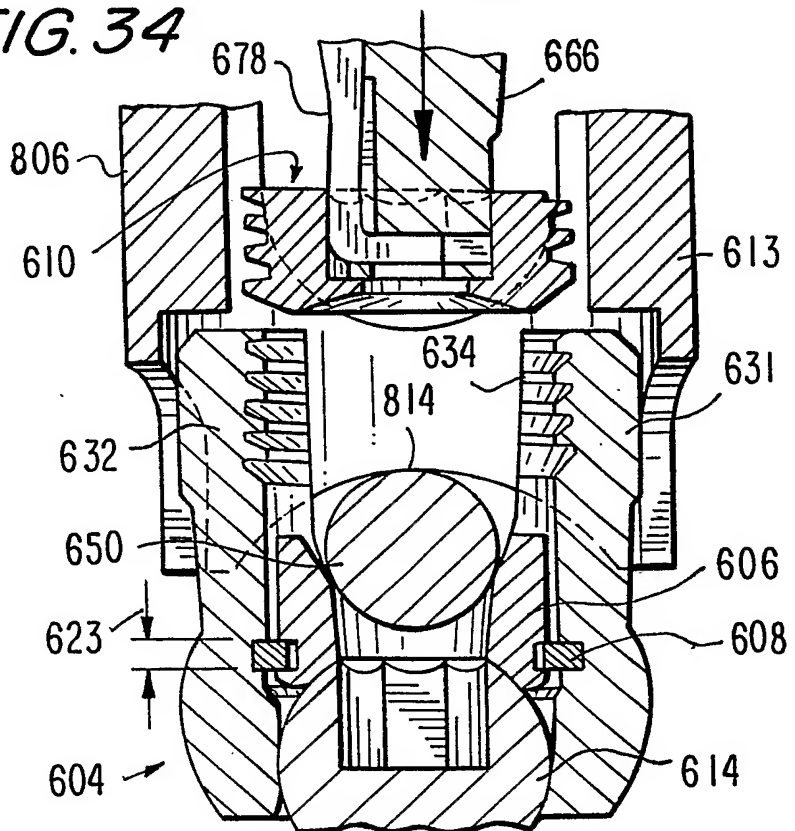
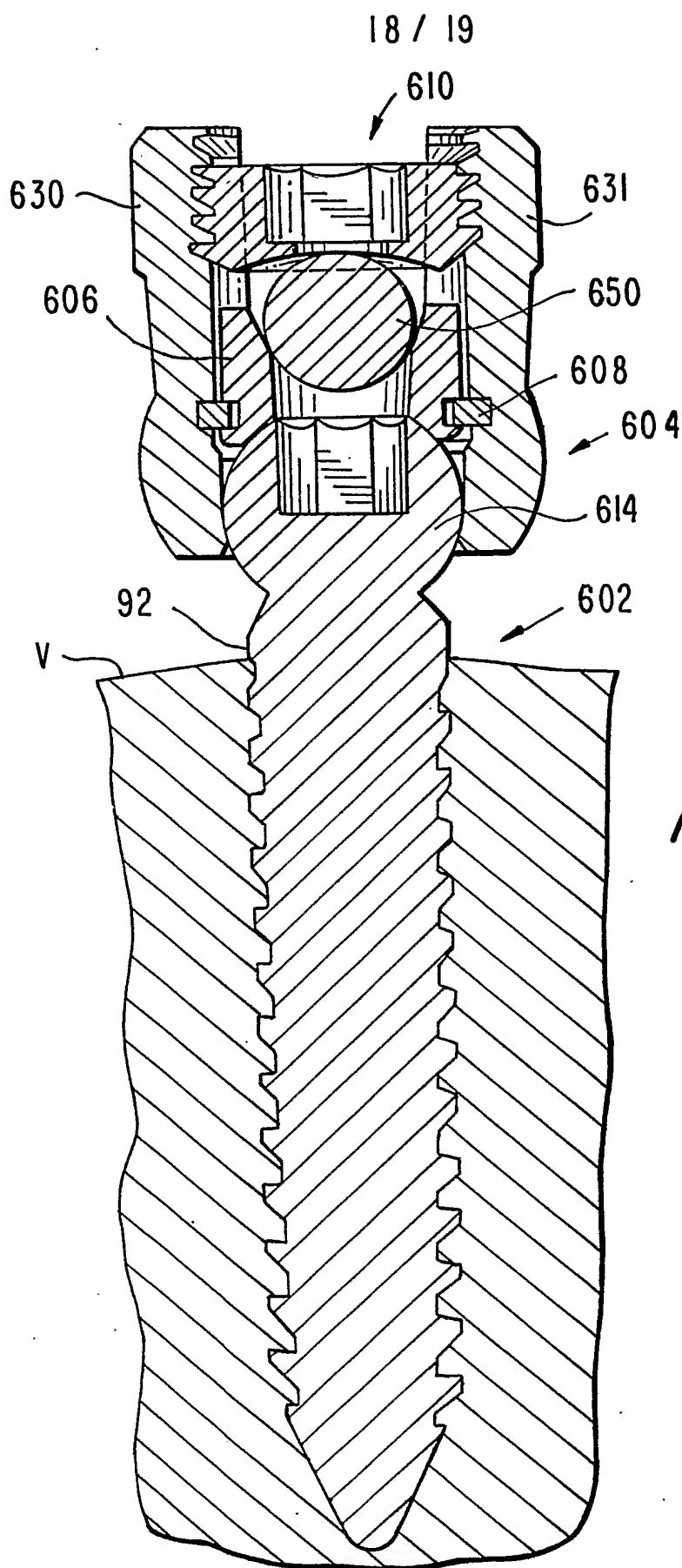


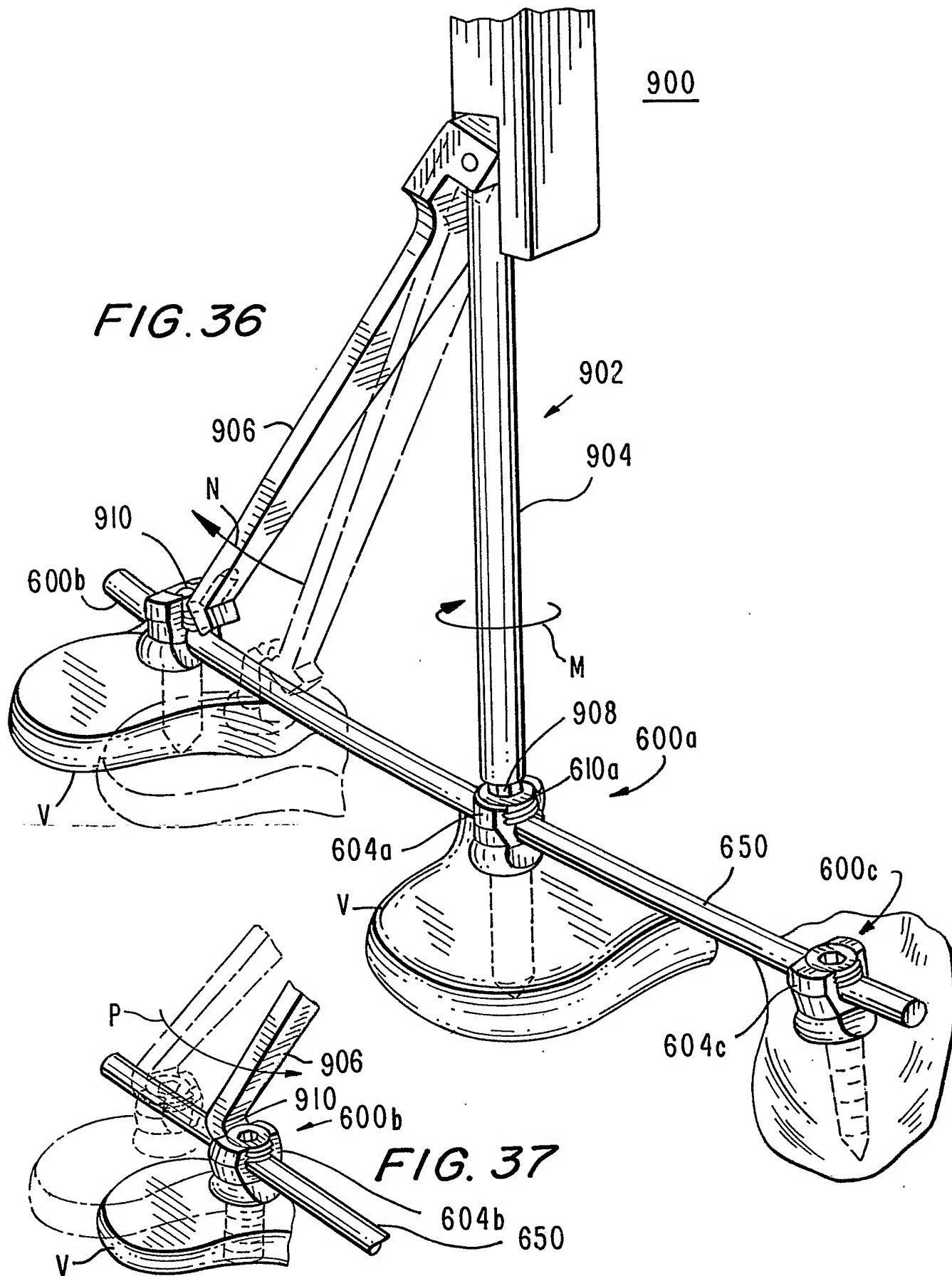
FIG. 34







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# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US02/28106

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : A61B 17/56

US CL : 606/61

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 606/61,72,73,99; 623/17.11

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST: vertebra\$, conduit, cannula, screw

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,368,321 B1 (JACKSON) 09 April 2002 (09.04.2002), see entire document.	1-8,12-13,15-17,20,31-38,42-43,45-
Y	US 6,187,000 B1 (DAVISON et al.) 13 February 2001 (13.02.2001), see entire document.	1-8,12-13,15-17,20,31-38,42-43,45-47,50

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search

14 November 2002 (14.11.2002)

Date of mailing of the international search report

**09 MAY 2003**

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